Plant Science Research Division
Cereal Crops Research Branch
Keim Hall, East Campus
University of Nebraska
Lincoln, Nebraska 68503

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Sorghum Newsletter

VOL. 3

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1960

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SORGHUM RESEARCH COMMITTEE

335 Keim Hall, East Campus
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SORGHUM NEWSLETTER

Volume 3

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In response to an appeal for financial support of the Newsletter, the listed organizations contributed $290. This aids materially in defraying costs of the present issue, and remaining expenses will be absorbed by the local Federal-State sorghum project. Appreciation is expressed to the following:

Asgrow-Texas Co.
Advance Seed & Grain Co.
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DeKalb Agricultural Association
Garst & Thomas Hybrid Corn Co.
Lindsey Seed Co.
W. O. McCurdy & Sons
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Pioneer Hi-Bred Corn Co.
Steckley Hybrid Corn Co.

If there are copies of Volumes 1 and 2 of the Newsletter that are not being used or not wanted, the Editor will be glad to find new homes for them since there are no remaining copies on hand. We have mimeographed 300 copies of Volume 3. In the present issue a few lengthy tables have been omitted from the manuscripts as submitted.

W. M. Ross, Editor
Ft. Hays Branch
Kansas Agricultural Experiment Station
Hays, Kansas
April 30, 1960

CONTENTS

		Page
I.	CONTRIBUTIONS	1
	Australia	1
	Brazil	1
	California	3
	Colorado	5
	Corn Products Company	7
	Florida	8
	Georgia	10
	Guatemala	14
	Illinois	15
	India	18
	Indiana	20
	Iowa	23
	Kansas	27
	Minnesota	28
	Mississippi	29
	Missouri and USDA	30
	Morocco	32
	Nebraska and USDA	33
	New Mexico	38
	Nigeria	39
	Noble Foundation	42
	Northern Rhodesia	43
	Oklahoma and USDA	44
	Pakistan	50
	Pennsylvania	52
	Pioneer Hi-Bred Corn Company	56
	Rockefeller Foundation	58
	South Carolina	64
	Spain	65
	Sudan	66
	Texas and USDA	71
	Uganda	78
	U. S. Department of Agriculture	80
II.	PUBLICATIONS	84
III.	MAILING LIST	91

I. CONTRIBUTIONS

AUSTRALIA

Hybrid Sorghum in Queensland

R. F. Moore (Warwick)

Seed of five cytoplasmic male-sterile strains were received by the Director of Agriculture, Queensland, and grown in quarantine during the winter of 1958. Small crossing plots were grown last summer, and nine hybrids are currently being grown in field trials at five locations. These trials have not yet been harvested, but several of the hybrids appear promising. RS 610 and RS 630 have the desired early maturity and show less tendency to lodge than some of the other hybrids, notably Texas 620.

Plants of male-sterile Combine Kafir-60 have appeared to be male-sterile so far, only one male-fertile plant having been observed in the many thousands of plants studied. Male-sterile Martin has produced fertile plants to the order of 0.1%.

The leading commercial varieties grown in Queensland are Alpha and Early Kalo. Alpha is locally bred and was first released in 1950. It acts as a restorer of pollen fertility, and the hybrids Combine Kafir-60 x Alpha and Martin x Alpha appear promising in trials at present.

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BRAZIL

Comments on Sorghum Production in the State of Pernambuco

Mario Coelho de A. Lima (Recife)

It is generally accepted that sorghum was introduced into Brazil by slaves at the same time and manner that it entered the United States. For unknown reasons it was not until recently that it became an economically important crop, being unknown in many regions where ecological conditions are better for this crop than for the corn.

Trying to find the reasons for this, experiments were planned for comparing the production from several varieties of sorghum with that of corn. These experiments were planted at Serra Talhada Experiment Station, Surubim Experiment Station, Caruaru Experiment Station and Cedro Experiment Station in Vitoria de Santo Antao, in the years of 1957, 1958 and 1959.

The Serra Talhada Experiment Station is in the semi-arid "sertao", 500 km from the ocean, with climate BSh in the Koppen Classification. The Surubim and Caruaru Stations are in the "Agreste" transition zone also climate BSh, but with more rain than the first station and located 100 to 140 km distance from the ocean. The Cedro Station is in a much rainier belt, climate Asi, and is 50 km from the ocean.

The rains at the first three Stations are sporadic, with averages around 20" in Serra Talhada, and 28" to 30" in Surubim and Caruaru. The rains at Cedro are much more dependable with an annual average of 38". The growing season depends exclusively on the rains that generally fall from March to August, during which the plantings of corn, beans and cotton are made. The temperature variations are very small, fluctuating between 75° and 85° F. from the coldest to the hottest months, and the length of day and night are almost the same during all the year (latitude 8° S.).

The production during the test years was very irregular, and the experiments failed 2 years in Serra Talhada by reason of deficient rains after the planting. Also many plots failed in the other places due to poor germination, insect attack and unknown reasons.

The plan consisted of 5 varieties of sorghum and 2 varieties of corn, with 4 replicates in each of the four locations. The yields are summarized in Table 1, the yield of sorghum being reported in relation to corn, which later was assigned a reference value of 100 in each of the respective tests.

Table 1. Comparative grain production of sorghum; relative corn yield=100.

Experiment Station	1957	1958	1959
Serra Talhada	402	0	0
Caruaru	76	102	69*
Surubim	260	100	77
Cedro	470	100	205*

*Production corrected for bird damage.

Observation of the detailed data from the individual tests shows:

1) The average grain production of sorghum varied from 0 to 1940 lb/A., and the production of corn from 0 to 2300 lb/A.

2) At Serra Talhada in 1957, the sorghum production was much higher than the corn. In 1958 and 1959 the rains were insufficient to mature either corn or sorghum.

3) In Caruaru and Surubim the sorghum and corn production were approximately equal. The plantings at these stations were made every year at the best time for the corn.

4) In Cedro the sorghum production was much higher than that of corn. The plantings at this station consistently were made out of season for the corn.

These preliminary results, which show contradictions from season to season and location to location, permit two very clear conclusions:

a) That in the places of deficient and sporadic rains the sorghum has a much higher possibility of successful production than corn.

b) In the places of better rain distribution, when the planting is made in the beginning of the rain season, the corn can produce more than the sorghum. Conversely, the opposite occurs when planting is delayed, as happened in all 3 years of tests at the Cedro Experiment Station. At this station non-experimental corn planted in the beginning of the rainy season produced much more than the corn yields from experiments reported here.

*****

CALIFORNIA

Effect of Within Row Spacing and Nitrogen Levels on Yield and Lodging of Three Forage Sorghums Under Irrigation

George F. Worker, Jr. (El Centro)

Forage sorghums have been grown commercially in the Imperial Valley of California for many years. Until recently Hegari and non-sweet types have been the predominant varieties grown. The development of sweet varieties for sirup production during the last ten years has given the farmer new varieties high in sugar content with increased yield over the Hegari or Atlas types. These varieties are taller, produce less grain per acre and tend to lodge under some conditions.

An experiment to determine the effects and interactions of plant spacing (population) and nitrogen levels on the yield, lodging and other factor sorghums was started in 1959.

Nitrogen rates (whole plots) of 0, 120 and 240 pounds per acre in the form of ammonium nitrate was applied preplant before making beds and the same rate side-dressed after the first cutting. Within row spacing (split plot) were 1", 3", and 6" obtained by planting heavy and thinning. The three forage varieties (Hegari, Atlas, and Brawley) were not randomized but planted in a solid block for ease of handling. This method is not the best to compare the variety x nitrogen or variety x spacing interaction and eliminated the variety x nitrogen x spacing interaction. Each variety was treated as a separate test.

The test was planted March 10, 1959, in a plot 5 beds (36") wide by 25 feet long and replicated three times. The center row was harvested for yield.

The production of Hegari was about the same as obtained in previous years with dry matter yields ranging from 2.94 to 5.00 tons per acre for the first cutting and from 0.97 to 8.50 tons per acre from the second cutting. The yield data were subjected to the analysis of variance from which a highly significant F value was obtained for nitrogen levels at both cuttings and spacing within rows for the first cutting. An F value significant at the 5% level was obtained from the first cutting for the interaction nitrogen x spacing (Table 1). Of the three varieties and two harvested crops this was the only significant F value for spacing or the interaction nitrogen x spacing. The highest production when comparing nitrogen levels was 4.82 tons the first cutting with 120 pounds of nitrogen and 8.15 tons the second cutting with 240 pounds of nitrogen. There was only 0.54 ton difference between 120 pounds and 240 pounds of nitrogen when comparing the total production shown in Table 2. The 1" plant spacing produced the highest yield at both cuttings with very little difference between the 3" and 6" plant spacing.

The production of Atlas was about average for the first crop and higher than Hegari, but the second crop was very poor producing less than Hegari. The F values obtained from the analysis of variance were highly significant for only the nitrogen level of the second crop. There was no yield difference between spacing at both cuttings or nitrogen level at the first cutting. Average yields from the first crop ranged from 5.30 to 6.88 tons of dry matter per acre and 1.22 to 6.39 tons of dry matter per acre for the second crop. When comparing the production of the second cutting for nitrogen level, there was no difference between 120 and 240 pounds of nitrogen but twice the yield of the no nitrogen plots. Lodging was not present in the first crop or the no nitrogen treatment of the second crop. In general, the 120 and 240 pounds nitrogen level lodged the same at all plant spacings.

Brawley production was excellent for the first crop, but the second crop dropped to the level of Atlas which is normal for the variety. Significant F values were obtained for nitrogen level at both cuttings. There was no yield difference in plant spacing. Production ranged from 6.13 to 11.59 tons of dry matter per acre for the first cutting and from 1.23 to 5.54 tons of dry matter per acre for the second cutting. The high nitrogen rate, 240 pounds from the first cutting, produced 2.80 tons more than the 120 pound rate and 5.24 tons more than the no nitrogen plot. The highest produced from the second crop was obtained at the 120 pound level but was only 0.21 ton above the 240 pound level. The no nitrogen plots produced very little second crop shown in Table 2.

Lodging of the first crop occurred in the 240 treatment with 27% at the 1" spacing while the other spacing lodged about 3%. Lodging in the second crop was general; even the no nitrogen plot lodged 2 to 3%.

The following general conclusion can be made for all three varieties:

1) Lodging was not sufficient or uniform enough in any treatment (spacing or nitrogen level) to pin down the factor effecting lodging. The higher nitrogen levels and plant population tended to favor lodging.

2) Spacing within rows of 1", 2" and 3" had little effect on yields, but the 1" spacing generally yielded slightly higher. There was no significant difference between row spacing except the first cutting of Hegari.

3) Nitrogen levels (0, 120 and 240 pounds per acre) showed the greatest effect especially the second crop. There was a significant difference at all the cuttings except the first cutting of Atlas. Brawley showed the greatest yield difference the first cutting with the high rate being superior. The biggest yield difference from the second crop was between no nitrogen and the two higher rates.

4) Nitrogen rates or plant spacing had no effect on anthesis dates or plant height for the first crop. Anthesis was delayed, and the number of plant headings was decreased in all no nitrogen plots of the second crop.

Table 1. F values of the analysis of variance for forage sorghum variety x nitrogen levels x within row spacing test.

Source	d.f.	Cut:	Hegari 1st	Hegari 2nd	Atlas 1st	Atlas 2nd	Brawley 1st	Brawley 2nd
Total	26							
Replications	2		1.22	.22	.02	.04	4.44	1.27
Nitrogen level	2		6.86**	213.37**	1.44	45.47**	59.64**	11.47**
Error A	2							
Within row spacing	2		13.53**	1.28	1.64	.06	.65	2.00
Nitrogen and spacing	4		4.31*	.60	.44	1.79	.55	.98
Error B	12							

*Significant at the 5% level.
**Significant at the 1% level.

Table 2. Effect of nitrogen level and within-row spacing on three varieties of forage sorghum yields.

Variety	Nitrogen level	1st cutting (Av. of all row spacing)	2nd cutting (Av. of all row spacing)	Total 1 & 2 (Av. of all row spacing)	Within row spacing	1st cutting (Av. of all nitrogen levels)	2nd cutting (Av. of all nitrogen levels)	Total 1 & 2 (Av. of all nitrogen levels)
	Lb./A.	Tons dry matter per acre			in.	Tons dry matter per acre		
Brawley	0	6.27	1.50	7.77	1	9.14	3.94	13.08
	120	8.71	5.17	13.88	3	8.93	4.12	13.05
	240	11.51	4.96	16.47	6	8.43	3.62	12.05
Atlas	0	5.57	1.29	6.86	1	6.44	4.29	10.73
	120	6.23	5.72	11.95	3	5.67	4.37	10.04
	240	6.13	5.85	11.98	6	5.82	4.21	10.03
Hegari	0	3.55	1.17	4.72	1	4.62	5.92	10.54
	120	4.82	7.76	12.58	3	3.80	5.39	9.19
	240	3.89	8.15	12.04	6	3.84	5.76	9.60

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COLORADO

Sorghum Investigations in Colorado

Warren H. Leonard (Ft. Collins), Herbert O. Mann (Springfield),
Floyd W. Frazier (Akron), Jerre Swink (Rocky Ford),
and Greg O. Hinze (Ft. Collins)

Combine-type grain sorghums continue to increase in popularity in Colorado, especially since the introduction of hybrids. A total of 9,913,000 bushels of grain was produced in the state in 1959, the third largest grain crop on record.

An estimated 50 percent of the grain sorghum acreage in 1959 was planted to hybrid varieties.

Dryland sorghum experiments are conducted at the Central Great Plains Field Station in northeastern Colorado at Akron, as well as at the Southeastern Colorado Branch Station near Springfield. Sorghum experiments under irrigated conditions are located at the Arkansas Valley Branch Station at Rocky Ford.

Irrigated grain sorghum experiments at Rocky Ford

When grain sorghums are considered over a 4-year period (1956-59), the average yield of 8 hybrids was 13.6 percent greater than the average yield of 12 ordinary varieties at Rocky Ford. The high hybrids produced average yields per acre as follows: Texas 620, 115.6 bushels; RS 610, 108.9 bushels; Texas 611, 108.2 bushels; RS 590, 105.5 bushels; and RS 650, 103.7 bushels. The highest ordinary variety was Bonita with a yield of 104.4 bushels, while Martin averaged only 87.5 bushels of grain.

About 80 early sorghum lines were studied at Rocky Ford as prospective parent material for grain sorghum hybrids. They originated from a breeding program conducted by J. F. Brandon at Akron for a number of years. A total of 55 of these Akron lines was crossed with Combine Kafir-60, Martin, Reliance, and Coes male-steriles. Of these hybrid combinations, 52 were included in a yield test in 1959. These involved 26 Akron lines crossed with ms Martin and with Combine Kafir-60. The hybrid combinations with Martin significantly outyielded those with Combine Kafir-60. Among these entries, 11 Akron selections proved to be fertility restorers. Akron restorer lines with desirable agronomic characteristics in hybrid combinations with ms Martin were: Ak 9-2, Ak 10-1, Ak 11-1, Ak 23, Ak 25-3, Ak 26-4, Ak 28-1, and Ak 42. Studies with the Akron lines will continue in order to develop early hybrid combinations.

Dryland sorghum experiments at Springfield

A grain sorghum yield test was conducted near Springfield on summer-fallow land in 1959. The highest yields were produced by RS 608 and RS 610. A white-seeded hybrid, H-6542, ranked third. Kansas 602 and Kansas 603 proved to be too late for the area. In spite of late maturity, good yields were obtained from Plainsman, Westland, and Texas 645. The average yield of 18 open-pedigree hybrids was 8 percent greater than that from 12 standard varieties. Well-adapted standard varieties outyielded poorly adapted hybrids.

A grain sorghum cultural experiment was conducted in 1959 with two common varieties, Martin and Early Hegari. Three rates of seeding were used, viz., 2, 4, and 6 pounds of seed per acre. These rates were seeded in two row widths, 21 and 42 inches. Although the results for seeding rates were not statistically significant at the 5 percent level, the highest yield was obtained from Early Hegari seeded at 4 pounds per acre in 21-inch rows. There was a significant difference in yield in favor of the 21-inch rows (13.1 bushels) over the 42-inch rows (9.9 bushels).

A three-year summary, 1957-59, shows that with the exception of Early Hegari planted at the rate of 6 pounds per acre in 42-inch rows, the 4-pound rate gave the highest yields of both standard varieties planted in either 21 or 42-inch row widths on dryland. More data are necessary to establish optimum seeding rates for this area.

Dryland sorghum tests at Akron

A grain sorghum yield trial was conducted under dryland conditions in northeastern Colorado at Akron. High yields on fallow land in 1959 were produced by RS 608, Grain Grass 7399-3-2-1-1, Reliance, Double Dwarf Yellow Sooner, and RS 501. Yields on sudangrass stubble land generally were poor.

In a sorgo variety test, RS 301F, a hybrid, was the only variety that significantly outyielded the Fremont check in pounds of air-dry forage per acre. Others that produced well were F.C. 34664, F.C. 34665, and RS 303F. All are hybrids.

A Grain Sorghum Composite Experiment at Akron

Floyd W. Frazier

A grain sorghum composite consisting of seed from 136 hybrids, 39 common varieties or pure lines, 30 selected rogues, and a small amount of seed bulked from 1219 F_2 selections was grown at Akron in 1959. The plan is to grow this composite in isolation each year, and also to enter it in the station sorghum variety yield test.

It is expected that those genes that improve adaptability to this region will increase in frequency through natural competition. Promising plants from the border rows of the yield test will be selected for the production of inbred strains. By studying the percentage of male sterile plants each year, it is hoped to approximate the competitive advantage due to heterosis.

By sub-division of the composite, and applying certain selection pressures, it may be possible to discover desirable mass selection procedures, as well as the effect of certain morphological characters on yield. Some of the selection pressures being considered are: later-than-optimum harvest of only the non-lodged plants; earlier than optimum planting; removal of a given percentage of seed by the fanning mill; and divisions according to awns, seed color, or endosperm color. The number of eventual subdivisions will be limited by the number of isolation plots available. Criticism of this program is invited.

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CORN PRODUCTS COMPANY

Carbohydrates in Grain Sorghum Kernels

S. A. Watson and Yoshiro Hirata (Argo, Illinois)

The nature of the carbohydrates in endosperm phenotypes of corn have been frequently studied. Although sugars have been analyzed in grain sorghum kernels by the usual chemical methods, paper chromatographic techniques have apparently not been used for separate analysis of constituent sugars in grain sorghum endosperm phenotypes. We have made a chromatographic analysis of sugars extracted from normal, waxy and sugary grain sorghums and herein report the results together with analysis of polysaccharides (Table 1). All samples were furnished by N. W. Kramer, Lubbock, Texas. Starch was extracted with calcium chloride and determined polarimetrically. Sugars were extracted with boiling 80 percent ethanol and

chromatographed on filter paper with butanol-ethanol-water (2:1:1). A water-soluble polysaccharide, similar to the phytoglycogen in sweet corn, was extracted with 10 percent trichloroacetic acid and precipitated with methanol.

Table 1. Carbohydrates in grain sorghums.

Variety	Genotype	g. per 100 g. grain, d.b.				
		Starch	Water-sol. polysacch.	Sugar	Fructose	Dextrose
Combine Kafir 54T	Wx Su	68.9	--	1.15	0.05	0.04
Waxy Kafir	Wx Su	69.3	--	1.39	0.14	0.14
Waxy Kafir, white	wx Su	68.6	--	1.07	0.09	0.09
Sugary Feterita	Wx su	56.7	7.9	2.96	0.38	0.34
Sugary Milo	Wx su	31.5	28.4	2.68	0.05	0.22
		Sucrose	Maltose	Unknown sugar	Raffinose	Fat
Combine Kafir 54T	Wx Su	0.84	0	0	0.13	3.9
Waxy Kafir	wx Su	0.95	0	0	0.12	3.8
Waxy Kafir, white	wx Su	0.77	0	0	0.09	4.1
Sugary Feterita	Wx su	1.97	0.05	0.05	0.13	5.6
Sugary Milo	Wx su	2.20	0.02	0.03	0.10	5.4

In the sugary varieties, starch content was lower, and water-soluble polysaccharide and sugar values were higher than in normal and waxy sorghums. The higher fat values in the sugary grains is probably an indication of the extent of shrivelling of their endosperms. Sucrose occurred as the main sugar component in all of the grain sorghums and increased most in the sugary compared with normal phenotypes. The content of raffinose, a trisaccharide, was apparently not affected by the su gene. The significance of the maltose and unknown sugar values in the sugary grains is not known. A small amount of sugars larger than trisaccharide account for the differences between the sums of individual sugars and the total sugar value. Sugary Feterita is distinctly different from Sugary Milo in starch, water-soluble polysaccharide and the ratio of fructose to dextrose. This may suggest a somewhat different genetic make-up. The composition of sugary milo is similar to sweet corn.

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FLORIDA

Bird and Disease Resistant Sorghums

F. T. Boyd (Ft. Lauderdale)

Serious depredations by birds and disease have delayed the acceptance of sorghum for feed purposes in southern Florida areas. Cuban guinea and Leoti-red varieties were found to have a high degree of resistance to these pests. Both of these varieties have open, spreading-panicle heads which by allowing air

circulation have lower losses from various fungi under high humidity conditions. These varieties also have awns attached to the lemma surrounding the sorghum grain which apparently act as primary deterrents against early bird depredation. Table 1 shows a grain yield comparison of these two varieties with other sorghums after a period of severe bird damage.

Table 1. Effect of bird depredations on harvested grain yield of several sorghums, Ft. Lauderdale.*

Variety	Dry grain in heads as harvested (percent)	Yield dry grain per acre (pounds)
Leoti Red	53.7	1,618
Cuban guinea	41.0	1,322
G I (African selection)	31.9	289
Sweet Sudan	26.9	280
Shallu	5.5	28
Nassau guinea	0.8	5

*Date of planting: October 24, 1958; date of harvest: February 5, 1959.

Fertility response of sorghum on sandy soils

Leoti Red and Cuban guinea sorghum varieties were planted February 3, 1959, with various rates and ratios of fertilizers, alone and in combination with high calcic, or dolomite lime. All treatments were in triplicate in plots 9 x 20 ft. in size on Arzell sand, Fort Lauderdale, Florida.

Highest forage yields were obtained by use of 1,000 pounds per acre of an 8-12-12 fertilizer containing one unit each of copper and manganese oxides. High calcic limestone was as beneficial as dolomite under the conditions of this experiment. Highest sorghum grain yields were produced by using a 1,000 pound application of 4-12-12 fertilizer with one unit each of copper and manganese oxides.

Effect of stage of growth on yield and protein content of sorghums

A determination was made of effect of stage of growth on yield and protein contents of seven sorghum varieties grown on Davie fine sand during the winter months at Ft. Lauderdale, Fla. Shallu measured only 3 feet in height after 60 days, while Leoti Red and Cuban guinea were each nearly five feet in height. Table 2 shows an average protein content of these sorghums of 14.52% when cut at 60 days as compared to only 7.92% when cut at 116 days. Longer day-lengths and higher temperatures during summer months would markedly affect the rate at which protein contents decrease.

Table 2. Effect of growth stages on forage yield, protein percent and protein yield of winter-grown sorghums. Average of seven varieties, Ft. Lauderdale.*

Age at time of cutting	Forage production		Protein percent	Pounds protein per acre
	Fresh yield	Dry matter		
	tons/acre	percent	(dry basis)	
60 days	5.99	21.6	14.52	374
77 days	6.02	34.9	10.19	422
103 days	4.96	29.6	8.84	222
116 days	3.94	32.6	7.92	193

*Planted: Oct. 24, 1958.
Dates cut: Dec. 23, 1958; Jan. 9, 1959; Feb. 4, 1959; and Feb. 17, 1959.

*****

GEORGIA

A. R. Brown (Athens)

Martin and Redbine-66 were dropped from the recommended list of varieties as there are higher yielding hybrids that are adapted to the Southeast. RS 630, NK 230 and 84E (Georgia Experiment Station number) were added to the recommended list of grain sorghums for Georgia. The recommended list of varieties and hybrids are as follows: Combine Sagrain, Wheatland, RS 610, RS 630, RS 650, Tex. 660, NK 230, DeKalb E56a, and 84E.

The acreage in grain sorghum has shown a sharp decline during the past two years from 90,000 to 40,000 acres. This decline has been brought about by favorable weather for high corn production. Should Georgia experience a dry summer in 1960, grain sorghum acreage would increase significantly in 1961.

60A and 25A, College Experiment Station hybrid yields were equal to or better than RS 610 in an irrigation experiment at the Southern Piedmont Conservation Field Station, Watkinsville, Georgia. 60A has the same parentage as RS 610 but has a more open head and is thought to be better adapted to the Southeast. 25A (A = Athens) is the result of the cross of Martin ms x Yellow Endosperm Sel. 2525A-1. It has a reddish yellow seed that is quite colorful. It is too tall for easy combining, having a height of 60 to 64 inches at Athens. It has possibilities as a dual purpose sorghum for the Southeast. Another hybrid, 64A, has the same parentage and performance as 84E (C. Kafir 60 ms x DDE Shallu) so will not be released. Two other College Experiment Station hybrids involving Midland and Caprock yielded well in 1959. Several good looking yellow endosperm lines are being included in new hybrids for future testing.

An electrical bird-scaring device, patterned after the Wyoming plan, was erected in 1959 with only fair results. It killed more songbirds than it did sparrows as the sparrows soon learned how to avoid it. Two factors limited the usefulness of the device, namely, location of plots between a cornfield and a farm fence and the height of the perch line (17 feet).

Several good looking red-seeded male steriles have been developed after 4 years of backcrossing. Male sterility has been transferred to Martin, Redlan, Wheatland, Red Combine Kafir Sel. 54-13, Western Blackhull x Day and Colby x Atlas.

In a pre-emergence observation plot four pounds of Simazin per acre reduced the stand of Martin grain sorghum 30 to 40 percent as compared to the check plot. Plants on the sprayed plots were stunted and were six inches shorter than plants on the unsprayed plot one month after planting. No yield measurements were made due to bird damage.

Size of plot studies

In 1957 Martin grain sorghum was harvested in five-foot segments from 12 rows, 90 feet long, making a total of 216 plots. Rows were 38 inches apart. Yields from these plots were combined in various combinations of rows and row lengths to determine the optimum plot size for grain sorghum yield trials. Coefficients of variability were computed for the different size plots after analyses of variance had been computed, assuming 9 entries. Four and six row plots, five feet long, have the lowest coefficients of variability (11.76 and 11.30 percent, respectively). Plot size of 2 x 3 gave a coefficient of variability of 11.85 percent.

In 1959 the size of plot experiment was repeated using hybrid grain sorghum, RS 610, in 40-inch rows. The number of plots were increased to 576 by using 24 rows each having 24 five-foot segments. Analyses of variance were computed assuming 12 entries. The plot sizes of 2 rows, 3 segments long (15 feet) and 4 rows, 1 segment long, gave the lowest coefficients of variability (10.45 and 10.60 percent, respectively). Therefore, the data of two separate years indicate that the most efficient plot size for grain sorghum yield trials is 4 rows, 5 feet long or 2 rows, 15 feet long.

Irrigation studies with grain sorghum

An irrigation experiment was started in 1959 using three levels of irrigation, two row spacings and eight varieties and hybrids. This experiment is in cooperation with the Southern Piedmont Conservation Field Station, Watkinsville, Georgia, and the Agricultural Engineering Department.

Three levels of irrigation employed:
1. None.
2. Irrigate at 10% available water in active root zone.
3. Irrigate at 50% available water in active root zone.

Row spacing:
1. 20-inch rows, plants 3 inches apart in row.
2. 40-inch rows, plants 3 inches apart in row.

Rainfall was well distributed during the 1959 growing season, and the crop was in the heading stage before a drought period occurred. Irrigation gave an increase in yield, but it was not significant. Row spacing did give a significant difference in yield. Average yield for the 20-inch rows was 81.1 bushels per acre and for the 40-inch rows 67.2 bushels per acre.

Sorghum Experiments in Georgia

H. B. Harris (Experiment)

Sorghum introductions

Approximately 550 Sorghum vulgare Pers. introductions were grown at Experiment, Georgia, during 1959 in cooperation with Grover Sowell, Jr., Plant Pathologist, Southern Regional Plant Introduction Station, Experiment, Georgia.

Data were collected on maturity, plant height, and disease susceptibility. Introductions in which anthesis occurred at appropriate times were used as pollinators in crosses with male sterile Combine Kafir-60. The F_1 progenies of these hybrids will be grown during 1960 and will be classified as to the presence or absence of restorer genes.

The data collected during 1959, along with data previously collected by J. C. Stephens and J. R. Quinby (Texas), College of Agriculture and Mechanical Arts (Puerto Rico), and North Central Regional Plant Introduction Station (Iowa) were compiled and published in a cumulative catalogue of sorghum introductions, which may be obtained by writing to Southern Regional Plant Introduction Station, Georgia Experiment Station, Experiment, Georgia.*

Stage of maturity apparently influenced the disease index (estimate of total severity of leaf diseases) considerably. In general, the strains classed as midseason or late received a lower disease index rating than did earlier strains.

Cercospora sorghi Ell. and Ev. was the most prevalent pathogen noted and accounted for a considerable portion of disease damage. Other pathogens in the approximate order of their importance were Helminthosporium turcicum Pass., Colletotrichum graminicolum (Ces.) G. W. Wils., Puccinia purpurea Cke., and Ascochyta sorghina Sacc. The frequency of stalk rots was low.

Bird control

Electrical bird repelling systems of the type described by Robert P. Pfeifer (Agron. Jour. 48:139-141. 1956; Agron. Jour. 49:338. 1957) were installed to protect the sorghum nurseries at Experiment, Calhoun, and Plains, Georgia, during 1959. Warren Marchant had previously installed a system at Tifton, and A. R. Brown installed one at Athens.

The bird species causing greatest damage at Experiment and Calhoun was the English Sparrow. Control at Experiment was approximately 80 percent and at Calhoun 100 percent. The difference in control at these two locations was attributed to faulty equipment and errors in installation at Experiment.

Wire spacers for the Experiment test were made from plexi-glass instead of double strength glass and leakage occurred between the wires at this point. The wires for this test were also stretched too tight, and this caused breakage and prevented sufficient contact when a bird was perched. As a result of these two errors, only a small percent of the birds that perched received sufficient shock to be effectively repelled.

*Ed. note: W. R. Langford, Coordinator, Regional Plant Introduction Station, Experiment, Ga., has indicated that small quantities of seed are also available for research purposes.

At Plains, the bird species that normally cause damage are sparrows and various blackbirds. The system at that location effected 100 percent control.

Control was reported good at Tifton and fair at Athens. The perch wire spacing at Athens was incorrect, and bird control decreased as the distance from the perch wires increased.

The Production and Evaluation of F_1 Hybrid Sudangrass

J. P. Craigmiles, J. P. Newton, and J. W. Dobson, Jr. (Experiment)

The utilization of heterosis manifested in F_1 hybrids is considered one of the more important breeding methods for increasing forage production. To successfully produce F_1 hybrids in sudangrass it is necessary that (1) suitable material be obtained, and (2) techniques usable with the material be developed.

At the Georgia Experiment Station cytoplasmic male sterility has been successfully transferred from Combine Kafir-60 grain sorghum to Rhodesian grass by a series of backcrosses using Rhodesian grass as the recurrent parent (Craigmiles et.al. Agron. Jour. 50: 714-715. 1958). All commercial varieties of sudangrass tested possessed genes for restoring fertility in Combine Kafir-60. S. arundinaceum (Rhodesian sudangrass, P.I. 156549) was the only sudangrass tested which did not have factors for restoring fertility; consequently, a male sterile was developed by using it as the recurrent parent.

With the development of a male sterile sudangrass, the production of F_1 hybrids is simply a matter of using the male sterile as a female, a good variety of sudangrass as the pollinator, and harvesting F_1 hybrid seed from the male sterile row at maturity. This is a procedure similar to that used in hybrid grain and forage sorghum production.

Average results of testing F_1 hybrid sudangrass and sudangrass varieties for three years at four locations in Georgia show the F_1 hybrids to be more productive than any of the open-pollinated, self-pollinated or synthetic varieties of sudangrass tested. Results of the evaluation and combining ability tests are summarized in Table 1. Three to four clippings were made at each location each year. The three-year average of these clippings are reported by location. In Georgia, varieties of pearl millet are more productive than sudangrass varieties; however, F_1 hybrid sudangrass produces as much forage as open pollinated varieties of millet but not as much as hybrid (Gahi-1) millet.

Table 1. Three-year average forage yield of sudangrass grown at four locations in Georgia, 1957-59.

Variety	Pounds dry weight per acre by location				
	Experiment	Plains	Calhoun	Blairsville	Average all locations
	pounds	pounds	pounds	pounds	pounds
F_1 Rhodesian x Tift	10,423	6,124	6,431	21,912*	11,222
Piper	7,750	5,185	4,496	15,179	8,152
Tift	7,621	4,282	5,182	15,486	8,142
Greenleaf	7,825	4,374	3,720	14,489	7,524
F_1 Sudax (Tift x C.K. 60)	11,268	6,746	6,397	26,352*	12,690
Stoneville Syn.	7,434	4,990	4,687	12,827	7,484
Average 10 other sudans	7,210	4,129	3,830	11,187	6,587

*Two year average

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GUATEMALA

Sorghum in Guatemala

Anibal Arriaga M.

The Guatemalan sorghum improvement program started in 1945 with a few introductions from the U.S.A. The best varieties suitable for our conditions to the date are Hegari, Caprock and Plainsman.

Comparative trial between introduced varieties and a local variety.

Variety	Days to maturity	Plant height m.	Head type*	Grain color	Yield kgs. per ha.	Rust** Puccinia purpurea
Hegari	85	1.50	SC	White	3,375	R
Caprock	90	1.00	SC	Reddish	3,000	MR
Plainsman	100	1.00	SC	Reddish	2,125	MR
Local	180	5.00	C	White	1,380	S

*SC = semicompact; C = compact
**R = resistant; MR = moderate resistance; S = susceptible

Beside foreign introductions 140 native collections are under study. These collections are available to other sorghum workers. Native sorghums are late varieties (6 months vegetative period), and they are low grain yielders, but yield good amounts of forage.

We are interested in grain sorghums as a substitute for corn mainly for cattle feeding in the dry regions of Guatemala.

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ILLINOIS

C. N. Hittle and P. W. Watkins (Urbana), G. E. McKibben (Dixon Springs), and D. R. Browning (Carbondale)

1959 performance trials

Extensive testing of grain and forage sorghum hybrids and varieties was started in Illinois in 1956. P. W. Watkins assumed charge of the 1959 testing program in which five grain and four forage tests were included at widely separated locations in the state. The results of these trials are reported annually in an experiment station bulletin. The tests are supported in part by an entry fee for each commercial entry.

In 1959 grain sorghum trials, 25 commercial hybrids, 9 experiment station hybrids and 6 standard varieties were tested. Average hybrid sorghum yields in central, western (on sand), south-central and southern Illinois were 93, 38, 71 and 92 bushels per acre, respectively, compared with corn yields of 102, 25, 82 and 82 bushels per acre, respectively. The 1960 grain sorghum tests on high production-potential soils and under anticipated favorable moisture conditions will be conducted at much higher plant populations than formerly used for the performance trials.

In 1959 forage sorghum trials, 13 hybrids were compared with 10 forage sorghum varieties and 3 adapted corn hybrids. The silage yields of forage sorghum hybrids have averaged about the same as yields of forage sorghum varieties during the past 4 years of testing. The average silage yield of corn has been considerably less than that of forage sorghum. However, the corn entries usually yield more grain per acre than forage sorghum entries. Several forage sorghum hybrids have a definite advantage over varieties in grain production, and compare favorably to corn in this respect.

Regional uniform nurseries

Uniform regional yield nurseries were grown in Champaign County on silt loam soil and in Mason County on sandy soil. The regional observation nursery was grown in Champaign County.

Rate of grain drying

In central Illinois, studies have been conducted for three seasons on the rate of drying of from 18 to 31 different grain sorghum hybrids and varieties. Associations between grain moisture and other plant characters are also being determined. The 1959 data are presently being analyzed, but information to date indicates that maturity is the only character that is strongly associated with rate of drying.

Plot size studies

A grain sorghum plot size study in Champaign County was designed and harvested in such a manner that the smallest units (6.6' x 6.6' plots) can be put together in various combinations to determine the optimum plot size. The trial was conducted

on both unthinned and thinned stands. The forage sorghum trial in Champaign County consisted of two 5 x 5 balanced lattice designs each in three replications with a plot size of two rows. Half plots (i.e., a single row) were harvested to obtain a measure of the sampling error. With this type of arrangement it should be possible to determine the optimum plot size and number of replications to use. The data from these trials are presently being analyzed. These studies will be conducted for at least two more years.

The effect of spacing within the row on yield and other characters of grain sorghum

This study was initiated in 1959 with the major emphasis being placed on number and size of spaces or "skips" within the harvest row. From such a study it might be possible to derive a mathematical formula to compensate for the blank spaces (if not too large). The 1959 spacing study was conducted by L. E. Klindworth and will be summarized in his M.S. thesis. These studies will be continued for at least two more years.

Genetic and Cytogenetic Research in Sorghum

Henry H. Hadley (Urbana)

In 1959 a project concerned with genetics and cytogenetics of sorghum was begun. The phases of research thus far initiated are described briefly in the following paragraphs. Some materials were already available from previous research not associated with this project.

Study of tall mutants in grain sorghum

A series of 10 tall mutants was obtained from J. R. Quinby who discovered them during an effort to eliminate tall mutants in lines of sorghum by selection. The mutants were in 4 families (4 from 7078, 3 from B-600, 2 from B-602, and 1 from 385). The first 9 were included in a test to determine whether or not each mutant within a family was simply a replication of one particular height mutant or whether some of the mutants within a family differed from others in the same family to form a multiple allelic series. A randomized block design containing 4 sibs (dwdw) from each mutant line in a family (derived from selfing Dwdw plants) was used to determine whether variation in genetic background existed in each family. A comparable test was used to test DwDw progenies (also derived from selfing of the same Dwdw plants). However, 4 sibs could not be guaranteed since DwDw and Dwdw plants could not be distinguished. At this time statistical analyses are not yet complete. No marked differences are apparent, however, among mutant lines within families.

Another test was conducted to determine the effect of a Dw gene on yield, maturity, etc. in several hybrid combinations such as RS 610. Crosses were made on Dwdw male sterile combine kafir plants using pollen from 7078, etc. according to the hybrid tested. The Dwdw plants traced back to a tall mutant in dwdw Combine Kafir-60 (male sterile). Resulting populations should have consisted of 2 genotypes differing at the dw locus (Dwdw vs. dwdw). Individual plant measurements were taken. The statistical analysis has not been completed. One difficulty encountered was the failure to obtain 2 distinct populations (Dwdw vs. dwdw). Environmental conditions were such, however, to cause considerable error variance. The test doubtless was not as sensitive as desired. These two studies were part of a masters research problem conducted by Jere E. Freeman.

A biometrical genetics study of height in sorghum

Mr. Phillip W. Watkins has undertaken a research problem for the Ph.D. degree which involves the study of inheritance of height in durra and height types of White Sooner Milo. The names of the parental materials with their proposed genetic constitutions for height are listed below (Quinby and Karper 1954).

Parents	Height in 1959 Urbana	Genotype
Durra	80"	$Dw_1Dw_2Dw_3dw_4$*
Tall White Sooner Milo	55"	$Dw_1Dw_2Dw_3dw_4$*
Dwarf White Sooner Milo	35"	$dw_1Dw_2Dw_3dw_4$
Double Dwarf White Sooner Milo	20"	$dw_1dw_2Dw_3dw_4$

*Durra and Tall milo differ by a modifying complex which shortens Tall about as much as a recessive gene.

In 1959 all parents, F_1's and 6 possible F_2 crosses were grown and observed. Backcrosses were made to each parent and F_1's were repeated. In 1960 parents, F_1's, backcrosses F_2's and F_3 families will be included for all 6 crosses. Data will be collected for height, time of maturity, etc. and analyzed according to Mather's method. Attempts were made to backcross F_2 plants to each parent in order to use Robinson and Comstock's method of separating components of variance. However, adequate amounts of seed which could be considered truely backcrossed seed were not obtained. The hot water technique was used but was not considered reliable though a system was devised for emasculating adequate numbers of plants.

Tetraploid sorghum

A program of collecting, producing, observing and selecting tetraploid forms of sorghum has been initiated. This material will be used both for breeding tetraploid lines of grain sorghum and for producing material of cytogenetic interest. No data regarding fertility or cytogenetic behavior have yet been obtained in any detail. However, F_1's have been produced between some lines, and this year one F_2 population will be available on a relatively large scale for selection.

Seedless, hybrid broomcorn

A program has been initiated to produce seedless, hybrid broomcorn which might be adapted to mechanized harvest of brush. This method will involve cytoplasmic male sterility and seed shattering. A proposed method has been described in a manuscript submitted to the "Agronomy Journal" for publication and entitled "A genetic method for producing seedless, hybrid broomcorn." First observations of crosses between male sterile Combine Kafir-60 and lines of broomcorn indicated a wide variation in male fertility among the F_1's. None was completely sterile though several were highly so. Others were quite high in fertility.

This may mean that broomcorn carries a major gene for restoration of fertility and modifiers which in some combinations can give high sterility. If this is true the problem of producing A and B lines in broomcorn may be difficult though possible to solve.

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INDIA

Sorghum Improvement at Parbhani (Bombay State)

D. S. Borgaonkar (Parbhani)*

Jowar (Sorghum vulgare Pers.) is one of the most important food and fodder crops of the Marathwada region of the State of Bombay. In this state, it is cultivated over an area of about 4,161,870 acres and yields on an average 1,600,000 tons of grain per year. Of this the area under Kharif crop (June to November - December) is about 1,932,088 acres and under Rabi crop (October to March - April) is about 2,229,782 acres. Jowar is the staple food of the people in this part of the country and is either cracked and cooked as rice or ground into flour for unleavened flat bread. Sometimes the grain is used for parching or popping.

Jowar improvement program was started at this station in 1928 by the erstwhile Government of Hyderabad. The objectives of this project were to release improved varieties for local cultivation and to suggest improved cultivation practices. The average rainfall in this region is about 35" per year which is distributed in the monsoon months, June to September, about 25" and winter months, November to January, about 10". The soil is of deep black clay type and is well suited for cultivation of Sorghum. The temperature range is 40° F. to 115° F. In the beginning selection work was done among the local varieties collected from the five districts of this region viz., Aurangabad, Bhir, Nanded, Osmanabad and Parbhani as well as from the jowar growing areas of other districts of the State. So far 15 improved Rabi varieties have been released for cultivation and some others which are under trial will be released shortly. Some of the most promising varieties suited for the agro-climatic conditions outlined above are: PJ3R, PJ4R, PJ5R, PJ7R, and PJ15R. (PJ stands for Parbhani Jowar and R for Rabi).

1. PJ-3-R--It is a selection from an indigenous local type of Dagdi jowar from Parbhani and has elliptical, very compact earheads with pearly white grains. The stem is 5' to 7' long and the maturation period ranges from 115 to 125 days. The grain yield per acre ranges from 500 to 600 lbs. and kadbi (dry fodder) yield per acre ranges from 2,500 to 3,000 lbs. The stem is slightly juicy and hence liked by animals. This variety is suitable for cultivation in Bhir and Osmanabad districts of this region.

2. PJ-4-R--It is an improved variety evolved by selection from an indigenous local type Maldandi from Bhir district. It has oblong and loose earheads with pearly white and bold grain. The stem is 5'6" to 7' long and the maturation period ranges from 120 to 125 days. The grain yield per acre ranges from 600 to 700 lbs. and this variety yields about 2,500 to 3,000 lbs. of kadbi per acre. It is well suited for the entire region of Marathwada.

3. PJ-5-R--It is an improved variety evolved by selection from an indigenous local type, Maldandi from Osmanabad district. It has compact earheads with pearly white and bold grain. The stem is about 4½' to 5' long and the maturity period ranges from 130 to 140 days. The grain yield per acre ranges from 450 to 500 lbs. and kadbi yield is about 1300 lbs. per acre.

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*Present address: Oklahoma State University, Stillwater, Oklahoma.

4. PJ-7-R--It is an improved variety evolved by selection from another Maldandi type of jowar from Osmanabad district with pearly white grains and black glumes. The stem is 5' to 7' long and has oblong and loose earheads. Its maturation period ranges from 120 to 125 days. It gives an average yield of 500 to 600 lbs. of grain and 2,000 to 3,000 lbs. of kadbi. It is suited for cultivation in Osmanabad and Bhir districts.

5. PJ-15-R--It is an improved variety evolved by selection from an indigenous type of Aurangabad district. The earhead is compact and grains are pearly white in color. The maturation period is about 150 days and the stem is about 6' long. Average grain yield per acre is about 700 lbs. and kadbi 3,000 lbs. It is suitable for cultivation in Osmanabad and Aurangabad districts.

Another improved variety PJ-16-R, which has been found to be very promising, will be released for cultivation very shortly.

On an average the improved varieties listed above yield about 10% more grain and 20% more kadbi (straw) than the local varieties.

Recently some work has been started to evolve hybrid sorghums by crossing these improved varieties with the cytoplasmic male sterile variety A385, received from Chandigar-Punjab. The hybrids thus produced were grown during the rabi season of 1958-1959 and have shown encouraging results. Further work is in progress.

Partial list of Indian sorghum workers.

Name	Address	Field of endeavor
Mr. L. G. Kolte	Millets Specialist, Government Main Experiment Station, Parbhaini, Bombay State	Breeding & Agronomy
Mr. N. H. V. Krishnamoorthy	Millets Specialist, Agricultural Research Institute, Rajendranagar, Hyderabad-6, Andhra Pradesh	Breeding & Agronomy
Dr. Dharampal Singh	Economic Botanist (Millets, oil-seeds, pulses), Kanpur, Uttar Pradesh	Breeding & Agronomy
Dr. G. P. Argikar	Economic Botanist's Section, College of Agriculture, Poona, Bombay State	Genetics & Breeding
Mr. B. S. Sharma	Micro Technical Research Labs. (Private), Dehra Dun, Uttar Pradesh	Breeding
Mr. C. Sreeramulu	Agricultural Research Station, Lam A.R.S., P.O., Guntur-2, Andhra Pradesh	Breeding & Agronomy

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INDIANA

1959 Sorghum Research in Indiana

R. C. Pickett and W. L. Whitehead (Lafayette)

The comparatively dry season (5.3" at Lafayette for June, July, and August compared to over 27" for that period in 1958) brought lower yields at all locations in 1959. The best group of hybrids (12) in the uniform nursery in cultivated rows yielded between 100 and 110 bu/A. at a population of 96,000 plants per acre which is still much higher than allowable in the Plains. Such population exhibited the necessary drouth resistance for this location and yet should allow yields of over 150 or 160 bu/A. that were obtained under favorable moisture in 1958.

Plantings in close (7 and 14") non-cultivated rows also stood drouth well, but the populations of 250,000 - 300,000 pl./A. and above proved to be less productive this year.

A disease nursery was planted for the first time in 1959. This work is cooperative with Dr. A. J. Ullstrup, Department of Botany and Plant Pathology. Field inoculations were made with Helminthosporium turcicum (from corn, grain sorghum, sudangrass, and johnsongrass), with Gleocercospora, and with bacterial stripe. Preliminary observations were made this year, and a report on this work with various foliar diseases of importance here will be made next year.

A study of possible interaction of various hybrids (15) was begun with variables of row spacing and degrees of high population under very high fertility. This study will be continued for several years with an attempt being made to develop a screening technique for the highest yield potentials of as many hybrids as possible.

Lodging notes were possible at this location for the first time with the classification and description being made of various types of inbreds with root lodging and different distinctive types of stalk breakage. A study is being commenced on the inheritance of the various type(s) of lodging. All single cross forage hybrids tested lodged severely at all locations in 1959 which points up the extreme limitation of lodging in the development and use of forage hybrids here. This is in striking contrast to the generally good adaptation and performance of the majority of single cross grain hybrids tested to date.

Grain sorghum testing program

Some of the problems of growing sorghum in Indiana are different from those encountered in drier areas. On fertile soils under conditions of good rainfall, height and tillering have sometimes been excessive. Due to limited rainfall in 1959, heights were not as extreme as in 1958. At one test location in northern Indiana on Muck soil however, RS 610 grew 6 feet tall and exhibited extreme height variability. Even though height variability seems to be greatest under good conditions, hybrids have differed enough to make high and low height data in addition to average heights, seem worthwhile.

Soil moisture is generally adequate in most soils, except in sands, in Indiana to keep sorghum in a rather active state of growth until frost. Several consequences often occur: lodging does not occur so readily, tillering may be increased, more care at combining is needed, and considerable green stover is left on the

ground of early combined fields. Tillering is generally worse in early maturing varieties planted too early. Considerable difference apparently exists, however, in the tendency of varieties of different maturities to tiller. Varieties which tiller profusely at a certain date of planting can give a distorted yield pattern in test plots of entries differing widely in maturity. Generally, however, full-season hybrids have given relatively better yields and have had less tillering. Full-season hybrids, as late as KS 701 and later, have matured successfully in most test plantings tried to date. Furthermore, after physiological maturity, a large range of moistures in the fall of the year have not been noted in several areas. Degree of head opening and date of flower have not been closely associated with drying in late fall. In many of the tests to date, some of the environmental conditions in Indiana have helped obscure differences which might have existed in the moisture in the heads at any time in the fall.

Utilization

One efficient program of fitting sorghum into the Indiana cropping system is worth mentioning. Graham Farms, Inc., Washington, Indiana, utilizes sorghum extensively in their livestock and mixed feed business. One of their objectives is to keep a ground cover at all times. The crop is generally seeded early. Part is interseeded later in the summer with rye or some other cover-crop. This has been done successively by airplane the past three seasons. Combining is done as soon as possible, long before frost (possible because of sandy soil). Wheat is planted directly behind the combine after nitrogen application. This procedure has been successful in spite of some difficulty in erradicating the growing sorghum crowns which send up profuse shoots. Wheat growth after sorghum has been somewhat poorer than after soybeans. Part of the crop is harvested directly by turkeys. This is accomplished by breaking over the plants with a jeep as needed by the turkeys. A portion of the stover left on the combined fields is used for silage. A chemical analysis from stover silage (ensiled while green) is:

	Plastic cover %	Open %
Protein	2.03	1.61
Fat	.40	.90
Fiber	8.75	5.60
H_2O	77.30	77.0
Carbohydrates	9.0	17.43
Ash	2.5	3.06

A good tonnage was realized in spite of low combining. Stover yields at Lafayette have averaged about 2.5 tons of ODM/acre for grain sorghum in hand harvested plots. Combined plots would be appreciably less however.

Chemical analysis by Graham Farms Laboratories

The 32 hybrids and varieties analyzed from a replicated test in Washington, Indiana, showed a considerable range in percent protein and percent oil. Percent protein ranged from 9.41 to 12.35% with the two check varieties, Martin and Dwarf Imperial Kafir being the highest. The % oil ranged from 1.83 to 4.64%. The % protein and oil seem far less important, however, when the total oil and total protein per acre are considered. Many of the highest yielding hybrids were relatively low in % protein. Martin hybrids RS 608 and RS 661 were lower in % protein than CK-60 Hybrids (RS 610 and RS 660). Even though there seemed to be a slight negative

relationship with yield the correlation was small and not significant. An analysis of variance was not possible since a composite sample of all the replications was used for the chemical analysis.

Forage sorghum

All forage sorghum hybrids lodged seriously at 4 locations in 1959 tests compared with Atlas at 7.5 to 10#/A rates of seeding. In close non-cultivated rows at the Southern Indiana Forage Farm, hybrids gave superior weed control because of greater seedling vigor early in the season. Atlas was the only variety which did not lodge appreciably in field scale 14" row plantings. Several hybrids have cut-yielded Atlas especially in close rows. It is apparent, too, that hybrid yields may have been reduced by lodging previous to physiological maturity.

Sudangrass

Hybrid sudangrass (DeKalb Hybrid SX-11, FC 34,666, FC 34,667, and FC 34,668) gave superior seedling vigor, and yields in 1959 compared to all varieties. Furthermore it appears that double and multiple cuts of these hybrids might put sudan hybrids in a favorable yield range for silage compared to forage sorghum on some sites. The growth rate of these hybrids is superior, but they are lower in proportion leaves than present varieties. Furthermore, resistance to Helminthosporium leaf blight of some of these hybrids has been superior. The prevalence of this disease, especially in southern Indiana, prohibits the growing of sweet sudangrass and other susceptible types.

Fertility Restoration of Cytoplasmic-genetic Male-steriles

A. B. Maunder (Lafayette)*

The following is an abbreviated summary on sterility research at Purdue. More detailed methods, results and discussion are to be published at a later date.

Frequency of fertility restoration factors

The frequency of some degree of fertility restoration (ms_c gene) as well as complete restoration was estimated by 2021 plants, representing 104 diverse varieties. Seed set readings were taken from 19,772 self-pollinated F_1's.

The mean frequency of the Ms_c factor for all entries was 0.61; that for complete restoration was 0.38. Certain varieties were found to be uniformly incomplete restorers. A close relation of origin of sorghum groups and the presence of fertility restoration factors was indicated. The kafir and forage groups were low in restoration as compared with milos, hegari-feterita types, and sudangrasses. Variations within a variety were attributed to original parentages or mutation. This variability likely remained in the variety because of a lack of selection pressure with normal cytoplasm.

Non-restoring nuclear factors were introduced into 19 of the varieties. Male-sterile F_2 segregates indicated sterile cytoplasm to be present in three varieties.

*Present address: DeKalb Agricultural Association, Lubbock, Texas.

This was further verified by "B" line backcrosses grown in the 1959-60 winter nursery. Extreme abortion was associated with two of the three sources, but this may be explained by the use of Combine Kafir-60 as the recurrent parent.

Fertility modifiers

Fertility modifiers such as complete floret abortion, tiller and primary culm fertility differences, and sectoring of male sterility within a head were studied. With a non-restoring genotype, sterile cytoplasm gave abortion although tillers had much less than the primary culm. Abortion was most common in the sterile and low pollen fertility classes. There was evidence indicating abortion to be directly related with the pollen fertility factors.

In general, tillers expressed a higher degree of fertility than the partially fertile or sterile primary culms. Also, variation was present among florets of partially fertile heads. Comparisons between seed set and stained pollen strongly favored the direct phenotypic approach for genetic studies of pollen sterility.

Inheritance of fertility restoration

The inheritance of fertility restoration was studied with both pollen and seed set readings being used to analyze F_1 and F_2 testcrosses, selfed testcrosses, F_2's and F_3's. An allele test of seven known restorers as well as five succeeding segregating generations of some partial fertile selections were studied.

Previous results, which indicated that a single recessive, ms_c, produced male sterility in the presence of sterile cytoplasm, were again confirmed. Restoration, however, apparently involves both epistatic and duplicate factors. Three-way crosses and testcrosses with Martin, Combine Kafir-60, and 7078, not only illustrated definite differences in the fertility genotypes of Martin and C.K.-60, but also led to a hypothesis of at least five genetic factors involved in restoration.

Only a low partial class was stable by the F_6. Evidence indicated some high partial classes were also genotypically stable, but phenotypically they showed a large standard deviation. A detailed genetic analysis of partial restoration will depend on evaluating a fixed genotype in a variable environment.

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IOWA

Grain Sorghum Research and Testing

R. E. Atkins (Ames)

Performance tests for grain sorghum hybrids and varieties were conducted at six locations in Iowa during the 1959 season. A total of 119 entries were made by six commercial companies, and several experiment station hybrids and varieties also were included at each location. Of the entries tested for the 4-year period 1956-59, RS 610 and Tx 660 have been the highest yielding hybrids and Martin the high yielding variety. Results obtained in 1959 and for the 4-year period are available in Agronomy Leaflet No. 488. The average yield for all grain sorghum

hybrids tested during this period has been essentially the same as the average yield for an adapted corn hybrid tested in adjacent plots at each location, and the higher yielding sorghum hybrids frequently have exceeded the yield of the adapted corn hybrid.

The M.S. degree thesis problem of Mr. I. A. Wikner on drying and maturity of grain sorghum as affected by water loss from plant parts has been summarized and is scheduled for publication in the August issue of Iowa State University Journal of Science.

The study of effects of freezing temperatures on seed viability and seedling vigor of grain sorghum was presented in the M.S. degree thesis of Mr. G. E. Carlson in May 1959. A journal paper and a note on techniques have been prepared from the thesis and are scheduled for publication in the Agronomy Journal in the May or June issue. A brief comment on the major findings follows.

Seed of Norghum, Combine Kafir-60, RS 501 and RS 610 was moistened to 20, 25, 30 and 35% moisture, and subjected to temperatures of 26, 20 and 14° F. for periods of 4, 8, 16, 36 and 72 hours. In a second phase of the study seed from plants maturing in the field was harvested at 15, 25, 35 and 45% grain moisture and subjected to the same temperatures, and all but the 72 hour duration. Seed of Combine Kafir-60 was reduced less in viability by most treatments than were the other hybrids and varieties. Seed containing 10 to 20% moisture was not reduced in viability by the freezing treatments, while grain of 30 to 45% moisture content generally was reduced markedly in germinability. For grain containing 25% moisture the reduction in viability varied from none to approximately 50% for the different temperature-duration treatments.

Comparison of results from the two phases of the experiment indicated that seed viability determinations obtained from sorghum grain remoistened to specific moisture levels and subjected to freezing temperatures, as a technique for determining differences in tolerance to freezing temperatures, likely would not give the same evaluation of varieties and hybrids as would similar investigations conducted with seed from maturing plants.

Seedling vigor was not reduced by the freezing treatments in either the soaked or maturing seed phase of the investigation. However, in the studies with maturing seed, the percentage of weak seedlings increased as grain of higher moisture content was subjected to freezing treatments.

Embryogeny and seedling development to floral transition in sorghum is being investigated by Mr. Ivan Paulsen as a Ph.D. thesis problem. Mr. Paulsen's graduate program encompasses a joint major in plant morphology and crop breeding and is under cooperative direction with Dr. John Sass of the Botany Department. It is anticipated that this work will be concluded and summarized during the fall quarter of 1960.

Evaluations for resistance to second brood corn borer infestation were continued in cooperation with Dr. F. F. Dicke and Mr. G. R. Pesho of the Regional Corn Borer Research Laboratory at Ankeny. In 1959, 38 sorghum varieties and hybrids were tested under a uniform infestation applied during pollen shedding. Using either sheath lesions or peduncle cavities as indices of resistance five entries stood out as highly susceptible to second brood borer attack. These varieties were D.D.Y. Sooner, Res. D.D.Y. Milo, Sooner, Texas Milo and Dwarf White Durra.

Varieties and hybrids exhibiting moderate susceptibility included Hegari, Martin, Redbine-60, Combine 7078, RS 590, RS 661 and KS 701. Varieties showing the highest level of resistance in this test were Feterita, Texas Blackhull Kafir, Pink Kafir, Red Kafir, Reliance, Ellis, Atlas and Fremont.

Observations of plant injury from borer infestation showed a high percentage of the stalk cavities to be in the peduncle. Although there was a highly significant correlation between sheath lesions and peduncle cavities, several varieties with a relatively high number of sheath lesions were low in stalk cavities. Peduncle cavities appear to provide a very satisfactory index for evaluating relative resistance to second-brood corn borer attack in sorghum.

Approximately $1\frac{1}{4}$ acres of DeKalb C44a grain sorghum were planted in rows spaced 40 inches apart at Ames in 1959 and thinned to a uniform stand of four plants per foot of row. The field was divided into 5-foot sections of row, and 2880 of these sections were harvested, threshed and weighed individually for use in a study of the efficiency of various plot sizes and experimental designs for yield test evaluations in grain sorghum.

Other studies continued in 1959 included the plant population and nitrogen fertilizer experiment, planting date and seed treatment studies, evaluation of pre-emergence application of selective herbicides on weed control and sorghum stands, and a study on the extent of reduction in yield and kernel weight from infestations of second brood corn borers. Results from these studies in 1959 either were inconclusive, or did not alter appreciably the comments presented in previous newsletters.

Breeding work continued with emphasis on attempting to combine early maturity and rapid drying characteristics with a good yield level, and a backcross program directed toward transfer of larger seed size from Egyption and Indian types to combine height strains adapted for this area.

Iowa Sudangrass and Forage Sorghum Tests, 1959

R. R. Kalton (Ames)*

Sudangrass

Eight varieties and 3 experimental hybrids of sudangrass, 2 seed lots of Sorghum almum, perennial sweet sorgrass, and 2 pearl millet hybrids were compared on a simulated pasture clipping basis at Ames in 1959. Three cuttings at monthly intervals were taken. In terms of good seedling growth, Piper, Sx 11 and Greenleaf appeared best, while Sorghum almum, pearl millet and perennial sorgrass were slow starters. Total annual yields for the sudan varieties ranged from 2.30 to 2.71 tons per acre with Greenleaf, Ga. 337 and Piper high and Sweet 372 and Stoneville Syn 1 low in yield. The pearl millet, Sorghum almum and perennial sorgrass entries all yielded within the range of the sudangrass varieties with perennial sorgrass on the low end. Two of the sudan hybrids yielded with the better varieties, but one, Tx A 3056-15 x R 3061, yielded 3.41 tons per acre. Helminthosporium blight was heavy on Sweet and Lahoma in September, moderate on Greenleaf, Piper and Oklahoma No. 8, and low on other entries.

*Present address: Rudy - Patrick Seed Co., Ames, Iowa.

These results show no superior performance of Sorghum almum or hybrid pearl millets over good sudangrass varieties under Iowa conditions. The high yield of one sudan hybrid, however, indicates possibilities of developing superior hybrids.

Forage sorghum

Four varieties and 17 hybrids of forage sorghum were tested at Ames, Iowa, in 1959 in comparison with RS 610 hybrid grain sorghum, Iowa 4570 hybrid corn and a New Mexico source of Sorghum almum for forage yield. Yields in tons per acre at 70% moisture varied from 19.7 for Rox Orange to 26.1 for Waconia Orange among the varieties. For the hybrids, yields ranged from 15.0 tons for a Texas experimental to 32.1 for FS 22. Generally, the later hybrids yielded more. RS 610 yielded 15.0 tons, Iowa 4570 corn yielded 20.6 tons and Sorghum almum yielded 19.5 tons per acre. Percentage grain at harvest time (hard dough stage) varied from a trace for RS 301F (bagged) to over 40.0% for some Texas experimentals and RS 610. Types with high grain percentage lodged badly if tall in height. The most lodging resistant entries were Waconia Orange, Sorghum almum, NK 3058, RS 301 (bagged), FS 22, NK 145, RS 610 and Iowa 4570 corn. Rust was bad in September, with NK 3059, Tx 605 x R 7210, RS 301, NK 145, NK 300, Iowa 4570 corn and FS 1A showing the least rust.

Two-year average performance of several varieties and hybrids at Ames is shown in Table 1. Results show that only Waconia Orange and RS 301F have been outstanding in performance in comparison with corn. A complete summary of 1959 results and 2- and 3-year averages appear in Agronomy Mimeo. 493, Jan. 1960.

Table 1. Two-year average performance for several sorghum hybrids and varieties in comparison with corn at Ames, Iowa, in 1958 and 1959.

Entry	Bloom date	Lodging (%)	Grain (%)	Tons/acre 70% moisture
Variety				
Waconia Orange	8-16	6	14.8	24.9
Atlas	8-21	11	18.6	20.7
Axtell	8-15	13	25.0	20.5
Rox Orange	8-16	23	23.3	20.1
Hybrid				
RS 301F*	8-13	4	Trace	23.0
FS 210	8-17	19	17.6	20.9
FS 1A	8-12	52	33.4	20.0
NK 300	8-13	41	32.5	19.6
NK 145	8-6	21	34.4	19.6
Grain hybrid				
RS 610	8-7	0	43.0	14.8
Corn				
Iowa 4570	8-2	0	35.1	20.4

*Bagged to prevent seed set.

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KANSAS

F. C. Stickler and A. W. Pauli (Manhattan)

With completion of the 1959 season, Jack Kersting finished his M.S. thesis study involving caryopsis development in Combine Kafir-60. Results obtained in 1959 were similar to those reported in the 1958 Newsletter.

Uniform row spacing-plant population tests were established this past year in cooperation with various experiment field and branch station personnel. Yield component information was obtained from four locations. In general, 20-inch rows were no better than 40's, and there was little tendency for a row spacing x plant population interaction. Soil moisture availability was probably the prime factor determining plant response to row spacing and plant population.

Optimum plot size studies were continued. Using C.V., it was concluded that a harvested plot area equivalent to one row 20 or 25 feet in length would be sufficient for obtaining reliable yield data.

The defoliation (leaf removal) tests established in 1958 were continued this year and the results have been summarized for publication in the Agronomy Journal. Based on this work, two new studies were initiated in 1959.

The phenology work is being continued as outlined last year. The IBM 650 is being used to process the data. Although temperature was found to account for 60 percent of the variation in time required for blooming in Norghum, no heat unit system attempted so far will predict maturity with any greater accuracy than calendar days.

Studies on the effects of GA (Gibberellic acid) on grain sorghum are being continued. Results to date suggest that foliar sprays repeated at a 2-week interval will afford the best chance of obtaining response. Seed treatment resulted in only temporary stimulation and no influence on grain yield.

In growth chambers, germination and seedling growth of 6 Kaoliangs plus 3 standard checks are being studied at temperatures ranging from 50 to 90° F. Certain Kaoliangs showed greater germination vigor and early seedling growth than was noted with the checks, Norghum, Midland or Redlan. This test is in cooperation with A. J. Casady.

A series of tests designed to compare different methods of planting grain sorghum was established in 1959. In general, use of press wheels was the major factor facilitating good stand establishment. Yields were closely related to stands.

Results from a test designed to study the performance of 4 genotypes grown alone and in various associations revealed that performance grown alone would predict performance of a variety when grown with other varieties.

Certified Seed Production in Kansas, 1959

Wayne Fowler and Tom Roberts (Manhattan)

The acreage of sorghums approved for certified seed production in Kansas in 1959 was 3022, or 86% of the 1958 acreage. Hybrid grain sorghum accounted for 1740 of the approved seed producing acres; only 550 acres of standard grain sorghums were produced.

1959 was fair to good for sorghum seed production. Generally good planting and growing conditions were offset by a wet fall and a rather early killing frost. The quality of seed varies throughout the state. Germination tends to average high, but discolored seed is the rule in much of the eastern two-thirds of Kansas. Prices have recovered somewhat compared to recent years.

Trueness-to-variety plots planted in the spring of 1959 lead us to believe there must be considerable improvement in Kansas hybrid sorghum seed production. Our concern over this led us to a winter growout test in Mexico. Several Kansas producers sent samples of their hybrid seed production for test. The results obtained have kept a few mediocre to bad lots off the market.

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MINNESOTA

Grain Sorghum in Minnesota

R. G. Robinson (St. Paul)

Until recently grain sorghum had no place in Minnesota agriculture, but high yielding hybrids, chemical weed control, and availability of grain drying equipment have begun to alter this situation.

In the humid northern corn belt, annual weeds are a major problem in grain sorghum production. Planting later than the recommended May 25 to June 10 period reduces the weed problem but often results in low sorghum yields.

Seven trials over a three year period have consistently shown that CDAA (Randox) at 4 lb./A. is an economically sound practice. CDAA increased yields in all trials and gave an average increase of 14 bu./A. Other than 2,4-D, it is the only herbicide recommended for sorghum.

Varietal trials at three locations on heavy soil for three years showed that the best sorghum hybrids outyielded corn under drouth conditions but yielded less than corn when rainfall was normal. RS 501 produced the highest yields and is of good maturity for southwestern Minnesota. NK 120 is a shorter hybrid that has also performed well. All hybrids tested will usually require artificial drying of the combine-harvested seed for safe storage.

Averaging all trials, RS 501 yielded 73 and Reliance variety only 46 bushels per acre. Adapted corn hybrids on the same fields yielded 81 bushels.

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MISSISSIPPI

Norman C. Merwine (State College)

As a possible means of midge resistance, cleistogamy was studied. Cleistogamy, as found in Nunaba, results when long, papery glumes are inrolled at the time of anthesis so that the edges of the glumes are "crimped" together and the anthers remain enclosed.

Since Nunaba requires short days for flowering, genetic work was carried out in the greenhouse during the winter. Two factors control cleistogamy. Indurate glume is dominant over papery glume. Rolled glume edge is dominant over unrolled glumes at anthesis. Rolling is expressed only in papery glumes, resulting in a 12:3:1 F_2 ratio of indurate: papery-rolled: papery unrolled glumes.

When F_3 and selected F_4 populations were grown in the field, nearly all plants were so late in maturity that they were not headed at the time of first frost in early November. In the F_4's which were considered to be homozygous for cleistogamy, no early plants were observed. In some of the F_3's there were a few early maturing plants, and a few of these plants were almost 100% cleistogamous. Anthers appeared to be normal within the cleistogamous flowers. Seed set on the cleistogamous heads was very poor (about 2-10%). Adult midge was present all during the season, but no midge larvae were observed in the sterile florets. The anthers appeared to have molded or failed to dehisce, so that self-pollination was not accomplished.

The use of cleistogamy for midge control does not look promising. One of the factors for cleistogamy in Nunaba may be linked to a gene, or block of genes, which result in the short-day response. Secondly, in the cleistogamous heads, the poor seed set is prohibitive. Limited further work is being considered, using very early maturing varieties and some of the shallu type glumes in order to more easily break the linkage if it does exist.

Grain sorghum continues to be a minor crop in Mississippi. The grain yield potential is good; however, in the past five years the harvested acreage has increased from 8,000 to 56,000 and then dropped to 30,000. During this time the state average yield increased steadily from 17 to 31 bu. per acre. State acreage apparently fluctuates in inverse ratio to rainfall during the previous year's harvest season. Seed damage by rainfall is perhaps the most serious production problem.

Brown-or tan-seeded types often have good resistance to seed weather damage, and offer one possible solution to this problem. Early harvest and artificial drying is being used in a few cases but is expensive.

For feed grain the storage of grain sorghum as a "head silage" has been tried and seems very promising. This method of storage saves the cost of drying, storage-insect control and special grain handling equipment, since it can be accomplished with minor modification of forage equipment. The use of grain sorghum for silage appears to be feasible in this area with yields and quality approximately equal to corn.

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MISSOURI and USDA

E. L. Pinnell and L. E. Cavanah (Columbia)

The fee-testing program was expanded to five locations in 1959. These trials are providing some very useful information to the commercial companies, to sorghum researchers, and to our farmers. The grain sorghum acreage in Missouri decreased from a high of 638,000 in 1958 to 507,000 in 1959. Average yield is reported at 50.0 bu. per acre.

Sorghum Germination

D. P. Srivastava (Columbia)

Sorghum hybrids and varieties were studied for germination in the laboratory, in cold tests, in three field plants, and in a minimum temperature germination trial. Performance of 1957 and 1958 seed lots (commercial) of the same varieties was not significantly correlated in any germination test. Cold tests were run at 8, 12, and 16° C. The 8° C. test correlated best with field germinations but was no better than the standard laboratory test for predicting relative stand difference under a range of field conditions. The minimum temperature for near normal germination of grain sorghum appears to be about 55° F. although radicle emergence occurred at 45° and 50° F., and the seed lot differences in percent radicle emergence were related to germination percent at 55° F. and to laboratory tests at alternating 68-86° F.

Grain Sorghum Weekly Sampling Study

A. C. McBride and M. S. Zuber (Columbia)

A weekly sampling study for grain sorghum was conducted for the 2-year period, 1958-1959, to determine the rate of drying, threshing percentage, and comparative moisture content for the whole head, stems and grain. The commercial hybrid, AMAK R12, was used, and the planting date was about June 1, each year. The plots were located on the University South Farm near Columbia, Missouri. The data are presented in Table 1. Samples were taken for an 11 week period in 1958 and for a 12 week period in 1959.

The results show little differences in threshing percentage when determined by either the green weight or the dry weight basis.

The stems contained more moisture on a percentage basis than either the whole head or the grain at a given sampling date. The comparative proportion of the moisture by weight in the whole head was less than that in the stems. Rainfall during the week prior to the sampling date increased the moisture content of the head, with the stems showing a proportionally greater increase. Precipitation which occurred during the week prior to November 1, 1958, and September 26 and October 31, in 1959, made this especially evident.

Dry weight ceased to be added when the grain moisture content was between 30 and 40 percent.

Table 1. Summary of weekly sorghum sampling study. Samples were taken at the University South Farm, near Columbia, Missouri.

Date harvested	Weight		Average of 6 head-sample				
			Threshing		Moisture		
	Green lb.	Air dry lb.	Green %	Air dry %	Whole heads %	Stems %	Grain %
	Forty-foot row		1958				
Aug. 30	26.0	11.5	88.0	92.5	53.5	70.8	51.1
Sept. 6	29.5	16.8	88.0	85.7	49.5	53.8	48.9
Sept. 13	33.0	20.8	84.0	93.0	32.0	56.5	26.8
Sept. 20	31.9	22.6	88.2	83.0	30.6	51.1	27.9
Sept. 27	30.5	22.9	87.9	90.5	28.4	43.8	26.3
Oct. 4	25.9	21.4	87.8	90.0	27.7	40.5	26.0
Oct. 11	26.9	22.8	83.7	86.7	20.7	35.3	17.9
Oct. 18	22.0	19.5	84.8	88.1	13.6	32.0	10.3
Oct. 25	21.8	18.3	87.3	89.1	10.6	23.8	9.1
Nov. 1*	26.2	21.2	89.7	91.3	14.5	28.1	12.9
Nov. 8	21.9	19.3	88.3	90.4	9.8	25.8	7.7
Mean	26.9	19.7	87.1	89.1	26.4	42.0	24.1
	Twenty-foot row		1959				
Aug. 22	10.5	4.9	89.1	90.0	58.9	63.2	58.4
Aug. 29	12.9	6.9	89.7	92.1	46.1	58.7	44.6
Sept. 5	13.7	8.9	88.7	92.1	39.6	58.9	37.2
Sept. 12	12.8	8.9	85.5	89.7	30.3	50.8	26.8
Sept. 19	11.3	9.3	86.0	90.5	21.0	46.3	16.9
Sept. 26*	13.0	8.5	85.8	91.2	32.5	58.3	28.3
Oct. 3*	12.1	9.4	86.3	92.3	23.5	56.9	18.2
Oct. 10	11.4	9.0	84.2	90.9	18.0	52.9	11.4
Oct. 17	10.0	8.5	86.4	89.2	14.3	32.3	11.5
Oct. 24	9.3	8.2	84.7	87.4	13.7	28.6	11.0
Oct. 31*	10.8	8.2	83.6	89.6	18.2	47.9	12.3
Nov. 7	8.0	7.2	89.6	91.9	7.9	28.9	5.4
Mean	10.7	8.2	86.6	90.6	27.0	48.6	23.5

*Rainfall for the week ending:
Nov. 1, 1958 - 0.1 inches
Sept. 26, 1959 - 3.9 inches
Oct. 3, 1959 - 2.2 inches
Oct. 31, 1959 - 0.1 inches

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MOROCCO

Drought Resistance of American Sorghums*

A. Cormu (Rabat)

American varieties and hybrids collected at the Agronomic Research Center, Rabat, coming from the Texas, Nebraska, and Kansas Experiment Stations were grown five years at Rabat without irrigation (annual rainfall = approximately 500 mm) in comparison with Moroccan and other African varieties (Tchad province). Observations were obtained on the grain yield per hectare, weight of 1,000 kernels, panicle length, number of panicles per square meter, and technological qualities such as flour yield and percent of protein in the grain.

The table below summarizes some observations on 15 of the most important varieties.

The mean yields obtained in the comparative trials followed the (randomized) block method; they are evaluated for quintals of grain per hectare obtained from dryland culture on poor sandy soils and protected from birds; the most resistant American varieties under these conditions appeared to be Darso 28 and Early Folgers. The variety, Nadara, from Tchad, has large red grains, is resistant to drought, and yields satisfactorily.

Bird damage is very important in Morocco; the ratings from 1 to 5 in the following table indicate: no damage (1) and much damage (5); these observations were made under cover in the presence of a limited number of birds; they indicate, consequently, an order of preference. The Moroccan varieties that had recurving heads were generally attacked little by birds; among the American varieties, Early Folgers, Darso 28, Redbine-66 and Martin were damaged less than the others; some were very susceptible, such as Pink Kafir. It was generally noted that the varieties with large grains (such as Nadara and Rouge de Taza) sustained less damage than the varieties with small grains.

These preliminary studies will allow the choice of basic varieties to form the selection and hybridization program at the Agronomic Research Center at Rabat.

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*Translation from the French by the Editor.

Variety	Origin	Yield - qx./ha.*				Wt. per 1,000 kernels (grams)	Flour yield %	Nitrogen in grain (d.m.b.) %	Bird damage
		1955	1957	1958	1959				
Early Folger	U.S.A.	--	7.1	18.8	20.7	20.5	--	--	2
Pink Kafir	U.S.A.	14.1	6.4	--	--	19.2	59	9.6	5
Bonita	U.S.A.	12.3	6.1	--	--	27.6	49	9.8	3
Rouge de Taza	Morocco	13.9	5.5	--	12.9	32.8	53	9.2	1
Rhafsai	Morocco	12.0	8.0	--	5.4	24.2	56	9.7	2
Nadara	Tchad	--	10.9	16.2	14.8	35.0	--	--	1
Hegari	U.S.A.	13.8	5.8	--	--	29.0	55	8.9	3
Yellow Sooner	U.S.A.	14.3	7.5	--	--	24.1	56	9.1	3
Redbine-66	U.S.A.	14.9	8.6	--	14.4	22.8	52	9.8	2
Darso 28	U.S.A.	12.4	--	18.1	16.8	20.1	59	8.6	2
Westland	U.S.A.	--	9.1	--	13.0	22.0	--	--	3
Midland	U.S.A.	--	4.5	11.8	8.6	22.3	--	--	3
Martin	U.S.A.	14.7	--	12.1	15.8	26.3	42	10.0	2
Combine Kafir-60	U.S.A.	15.2	7.1	16.5	10.6	24.5	51	8.6	3
Caprock	U.S.A.	--	--	21.3	14.4	24.7	--	--	4

*Metric quintals (100 kg.) per hectare.

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NEBRASKA

Notes for the 1960 Sorghum Newsletter from Nebraska

O. J. Webster (Lincoln)

In 1959 1,306,000 acres of grain sorghums were harvested in Nebraska. This figure is 318,000 acres or 20 percent lower than that for 1958. The grain sorghum crop totaled 59,423,000 bushels, the third largest on record. The average yield of 45.5 bushels per acre was second only to the record high of 48.0 bushels in 1958. The production of grain sorghum was double that of oats.

The percent of the acres in Nebraska planted to hybrids in 1958 was 46.8, and this figure approached 75 percent in 1959.

Seed of eight grain and one forage hybrid was produced under certification in 1959. The acreage planted for hybrid seed production held rather constant at about 3000 for the past three years. The number of growers in 1957 was 138. This number dropped to 112 in 1958 and to 95 in 1959. Two growers planted 58 acres for seed production of RS 301F.

Data from four studies conducted in 1959 are presented and discussed.

Plant-population study

A study has been under way in Nebraska during the past 3 years to determine the relationship of the components of yield of varieties with hybrids. There is some indication that the relative yield advantage of hybrids decreases as yields increase. The maximum yields obtained to date are about 125 bushels per acre. An effort was made to exceed this production figure in 1959 by planting a test in 20-inch rows on an area which had been given a preplant application of 200 pounds of nitrogen. The soil was wet to at least 6 feet at planting time and a 5- to 6-inch application of water was applied just before heading. A total of nearly 11 inches of precipitation was recorded for the period from June through September. Martin and RS 610 were planted, and the plots harvested were thinned soon after emergence to 4 and 6 inches between plants which represents a plant population of 78 and 52 thousand plants per acre.

The yields of the plots with plants spaced 4 inches apart were higher than those with the plants spaced 6 inches apart, but the difference was not statistically significant at the 5-percent level (Table 1). The point of interest in this test is why the yields did not exceed 126 bushels. The test will be repeated in 1960 with different fertility levels and additional applications of water if required.

Table 1. Yields and other agronomic data from grain sorghums planted in 20-inch rows, irrigated once, 200 pounds of nitrogen applied preplant, Lincoln, Nebr., 1959, (averages of 5 replications).

Entry	Plant spacing	Seed weight		Seed volume	Density	Weight	Yield
		per head	per 1000	per 1000		per bu.	per acre*
	in.	gm.	gm.	ml.		lb.	bu.
Martin	4	.079	21.1	16.0	1.32	58.3	101
Martin	6	.102	21.6	16.7	1.30	58.0	96
RS 610	4	.107	22.9	17.9	1.28	56.2	126
RS 610	6	.126	23.3	18.3	1.27	56.4	122

*Yield differences between plant spacing not significant at .05 level.

Plot size

In the 1959 Newsletter results of a study to determine the minimum plot size which can be efficiently used to conduct a sorghum-yield test were reported. The study was repeated in 1959, but stands were not good enough for it to be harvested and the data analyzed as in the previous test. Four-row plots of RS 610, RS 590, and Martin were planted in four replications. The plots were thinned to 6 and 12 inches between plants. Because of imperfect stands four 5-foot sections were harvested from each plot. There were 5 plants in each of the sections when the plants were spaced at 12 inches and 10 in those when the plants were spaced at 6 inches. Yields were calculated for one 5-foot section per plot and two, three, and four sections (Table 2). The greatest deviation in yield of a plot based on a one 5-foot section from a combination of four, or a 20-foot plot, was 3 bushels. The yield reduction for plots with plants spaced 12 inches apart was 20 bushels for all entries. This was a 33-percent reduction for the hybrids and a 44-percent for the variety.

Table 2. Yields of sorghum calculated by combining four 5-foot subsamples per plot, Lincoln, Nebr., 1959, (averages of 4 replications).

Entry	Plant spacing in rows	No. of sub-plots combined	Plot length	Yield per acre
	in.		ft.	bu.
RS 610	6	1	5	79
		2	10	82
		3	15	81
		4	20	82
RS 610	12	1	5	62
		2	10	62
		3	15	62
		4	20	62
RS 590	6	1	5	74
		2	10	79
		3	15	76
		4	20	77
RS 590	12	1	5	59
		2	10	55
		3	15	57
		4	20	58
Martin	6	1	5	64
		2	10	67
		3	15	66
		4	20	66
Martin	12	1	5	44
		2	10	46
		3	15	45
		4	20	45

Comparison of F_1 and F_2 generations

Seed of the F_1 and F_2 generations of four hybrids was planted in a test with a split-plot design at Lincoln and North Platte. At Lincoln every third plant in each row was tagged until 10 plants were tagged. Blooming and height notes were recorded for these plants. The maximum yield reduction of the F_2 over the F_1 was 18 percent for RS 501 (Table 3). The yield of the F_2 of RS 650 was about equal to that of the F_1. The plants in the F_2 plots bloomed from 1 to 3 days later than the F_1's, and the F_2 plants of RS 501, RS 590, and RS 610 averaged a few inches shorter in plant height.

Table 3. Comparative yields and other agronomic data of F_1 and F_2 generations of four grain sorghum hybrids grown at two locations in Nebraska, 1959, (average of 5 replications).

Hybrids and generations	Days to bloom	Plant height	Threshing percentage	Yield per acre		Ratio F_2 to F_1
				Lincoln	North Platte	
	no.*	in.*		bu.	bu.	
RS 501 F_1	55.8±1.4	51.1±2.4	83.4	88	54	
F_2	58.2±2.1	45.4±4.4	80.2	67	50	82
RS 590 F_1	61.6±1.2	42.9±2.2	78.7	84	53	
F_2	63.3±1.7	41.7±3.1	78.7	76	49	92
RS 610 F_1	60.7±1.0	41.6±2.4	76.3	89	65	
F_2	63.1±1.6	39.3±4.6	76.3	76	54	85
RS 650 F_1	62.0±0.9	36.2±1.6	76.2	77	49	
F_2	63.2±1.9	37.6±3.1	77.4	77	48	99

*Standard deviations of 10 plants per row at Lincoln.

Stigma-receptivity study

A summary of a stigma-receptivity study conducted at Hays, Kansas, in 1958 was reported in the 1959 Newsletter, and the data were combined with data collected at Lincoln, Nebraska, and published as a Note in the Agronomy Journal Vol. 51:632, 1959. The 1958 tests were conducted under conditions considered optimum for prolonged stigma-receptivity. The study was repeated at Lincoln in 1959, and the pollinations were made early in August. Weather conditions at this time were more nearly like those expected when the plants in seed-production fields are heading. The results obtained in 1959 (Table 4) were similar to those reported from the 1958 tests. The period of stigma-receptivity for the cytoplasmic sterile lines Martin, Redlan, and Westland extended to 3 or 4 days after the heads were in full bloom. Good seed sets were obtained on Combine Kafir-60 for 6 days. The relatively poorer seed sets reported for Martin and Combine Kafir-60 on the 0 and 1 days were due to a limited amount of pollen available because of rains on these days.

A study was also made to determine the period of stigma-receptivity when the heads are protected by paper bags during and after anthesis. Previous reports from such studies have shown that stigmas will remain receptive for several days when so protected. The results obtained in this test, however, show that good seed sets were obtained only 4 days after full bloom (Table 5). This relatively short period of stigma receptivity was partly due to a rapid "buildup" of aphids under the bags. The bags used had been treated with dieldrin.

A few seed set on unpollinated bagged heads of Westland. The sterility of this sterile line was good at Lincoln in 1958 but relatively poor at Hays, Kansas.

Table 4. Seed set on unbagged heads of cytoplasmic male-sterile sorghum when pollinated daily, Lincoln, Nebr., 1959.

Days after full bloom	Estimated seed set*				Av. wt. of seed per head*			
	Combine Kafir-60	Martin	Redlan	Westland	Combine Kafir-60	Martin	Redlan	Westland
no.	%	%	%	%	gm.	gm.	gm.	gm.
0	75	58	96	93	32	28	83	51
1	45	61	96	81	31	34	89	47
2	98	89	92	86	71	81	79	58
3	95	59	89	69	54	43	62	58
4	95	65	56	47	54	53	47	25
5	73	37	5	1	41	34	18	3
6	88	2	18	7	45	7	36	10
7	34	7	7	24	23	12	22	18
8	2	**	0	0	10	2	0	0
9	0	**	**	0	4	1	5	0
10	**	0	**	0	1	0	4	0

*Four or more heads pollinated on each date.
**Less than 1.

Table 5. Seed set on bagged heads of cytoplasmic male-sterile sorghum when pollinated at 2-day intervals, Lincoln, Nebr., 1959.

Days after full bloom	Estimated seed set*				Av. wt. of seed per head*			
	Combine Kafir-60	Martin	Redlan	Westland	Combine Kafir-60	Martin	Redlan	Westland
no.	%	%	%	%	gm.	gm.	gm.	gm.
0	99	98	98	97	62	85	61	66
2	98	88	88	48	53	51	59	30
4	99	93	69	25	13	61	44	21
6	1	2	33	1	5	8	21	4
8	**	**	2	**	1	0	5	2
10	0	0	5	5	0	0	7	10
12	0	0	**	0	0	0	1	3

*Four heads pollinated on each date.
No seed set on unpollinated heads of Combine Kafir-60, Martin, or Redlan.
A few seeds set on 9 unpollinated heads of Westland; none set on two heads.

**Less than 1.

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NEW MEXICO

Charles E. Cypert (Clovis)

Production

New Mexico farmers produced 8,800,000 bushels of grain sorghum in 1959, 9 percent more than last year despite a 10 percent reduction in acreage. Yield per acre is estimated at a record high of 40.0 bushels per acre as compared with 33.0 bushels last year and the 1948-57 average of 15.9 bushels per acre. Production of broomcorn is estimated at 7,300 tons as compared with 7,900 tons in 1958. Harvested acreage, estimated at 43,000 acres is 14 percent below 1958, but yield per acre of 340 pounds is 8 percent higher. Sorghum silage production of 322,000 tons of green material was almost twice the amount harvested in 1958. Dried sorghum forage production was estimated at 110,000 tons of air dry forage.

Variety evaluation

In an irrigated yield trial conducted by the Plains Substation in 1958, KS 701, RS 610, RS 590, and Texas 620 were the top yielding entries with yields of 91, 87, 85, and 78 bushels per acre, respectively. However in dryland trials the highest yielding entries were Texas 660, RS 630, NK 210, and RS 610. The top yielding varieties tested on dryland in 1959 were Combine Kafir-60, DK x 1103-10-1-741, Plainsman, and Westland. Generally those hybrids about the same maturity range of the variety Martin have been the leading producers in this area under dryland conditions whereas later maturing ones, such as Texas 660, have been highest yielding under irrigation.

Tracy, Brawley, DeKalb FS-22 and Asgrow H5819 were the top yielding of 22 forage varieties and hybrids tested. It has been noted from results obtained in 1958 and 1959 that many of the hybrid forage sorghums are definitely lacking in sweetness of stalk as compared to some of the standard varieties.

New work

Row and plant spacing studies with RS 610 and Combine Kafir-60 were initiated in 1959. Row spacings of 20 and 40 inches and plant populations per acre of 10,000; 20,000; 30,000; 40,000; and 50,000 are being used.

Evaluation studies with early maturing grain varieties for possible use in mid-July plantings were also begun in 1959. Varieties used were Ryer 15, Imperial 40 Milo and DD Early Hegari.

Bird Control and Variety Testing in Southeastern New Mexico

A. Kent Nielson (University Park)

Grain and forage sorghum grown under irrigation in the Pecos Valley of southeastern New Mexico is generally subjected to a considerable amount of bird damage. Because of this damage reliable information from small experimental plots is practically impossible to obtain when birds are not controlled.

In order to conduct grain sorghum trials at the New Mexico State University substation located at Artesia, New Mexico, a high voltage bird-control apparatus, essentially the same as the one described by Pfeifer (Agron. Jour. 48:139-141, 1956) was installed. This device consisted primarily of two parallel wires spaced 2½ inches apart around the perimeter of the test area at a height of approximately 12 feet. When functioning properly, electricity arced from one wire to the other at irregular intervals causing a crackling, snapping noise which very effectively frightened away birds. Shorts developed periodically in this system by twisting of one wire over the other, by breaking of wire spacers, by burning out of insulators at support poles and by electrocuted birds falling across both of the parallel wires. All shorts caused the apparatus to become inoperative. As long as the system was in working order birds did not approach the enclosed area. Use of heavy duty wire spacers and insulators would have permitted longer periods of trouble-free operation and fewer repair bills.

In 1959, grain sorghum, forage sorghum and sudangrass variety tests were conducted within the electrically protected area. Another test composed of 27 grain sorghum varieties or hybrids was planted in an unprotected area. Birds, chiefly sparrows, blackbirds and mourning doves, consumed every grain of all varieties and hybrids tested in the unprotected area. In the protected area bird damage was negligible.

Based on one year's data, the following varieties or hybrids were highest in yield of those tested:

Grain sorghum-- DeKalb F-63, Texas 620, DeKalb C-44a, DeKalb D-55, Texas 660, Northrup King 230 and Redlan. Yield of DeKalb F-63 was 119 bushels per acre.

Forage sorghum-- Asgrow H5820, Asgrow Beefbuilder, Tracy and FS-22. Yield of Asgrow H5820 was 8.53 tons of dry matter per acre. Lodging was severe only for Asgrow Silo King.

Sudangrass-- Piper, Greenleaf and Wheeler. SX-11 and Sorghum almum were included in the test and outyielded the sudangrass varieties. SX-11 produced 8.3 and Piper 7.5 tons of dry matter per acre.

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NIGERIA

Some Aspects of Sorghum Improvement in the Northern Region of Nigeria

D. J. Andrews and D. L. Curtis (Samaru)

Sorghum is grown throughout the Northern Region between the latitudes 7° - 13°50' N., at altitudes ranging from 400 ft. - 2,400 ft. above sea level.

With the exception of the derived savanna zone (Keay 1953), where root crops and maize are widely grown and parts of the Sudan and Sahel savanna zones where millets (Pennisetum spp.) are more important, sorghum is the staple cereal. It is predominantly a rain-fed crop. The mean annual rainfall varies from 60" - 80" in the south to 20" - 30" in the north.

The crop is usually grown on ridges approximately three feet apart at spacings which give plant populations of 14,000 to 17,000 plants per acre. In low rainfall areas cultivations may be on the flat. All cultural operations are carried out by hand except in those areas where mixed farming is practiced. In most cases the grain is used for human consumption although in some areas red grained cultivars are used for brewing. The average yield per acre does not usually exceed a thousand pounds of threshed grain and the annual production for the Northern Region is estimated at just over two million tons. Although none of this is exported there is considerable internal trade carried on between areas of low and high production. The stems are used for various purposes including fuel, fencing and building, or they may be burned over the land. The non-juicy leaves are invariably fed to the livestock. Other types which are grown include sweet sorghums whose stems are chewed like sugar cane, and types whose dark, pigmented leaf bases are used for the extraction of a dye.

The improvement of sorghum under these conditions is not likely to be an easy task. A comprehensive sample survey was carried out in 1957/1958. A total of 750 completed questionnaires together with the relevant head samples were sent by extension officers from all provinces to the Regional Research Station. At Samaru the samples were recorded, photographed, measured and threshed. During threshing, racemes were retained for reference and further classification studies. A preliminary distribution map of the main agronomic types has been prepared. This survey shows that although each district or even village has its own cultivars, large areas grow a similar type of sorghum. In the Guinea and sub-Sudan zones (Clayton) the predominant type corresponds to what Snowden (Snowden, 1936) describes as Sorghum guineense, Stapf. In the Sudan zone the position is more complex, but most of the types would be referred by Snowden to the sub-series Caffra. Difficulties have been experienced in using Snowden's classification.

There is a wide variation between these agronomic types and when those of no economic importance are also considered it seems justifiable to regard Northern Nigeria as a center of diversity, although perhaps not on the same scale as that described by Evelyn (Evelyn 1951) for the Sudan. The opportunity to study the relationships between Nigerian and Sudan sorghums occurred when Professor A. H. Bunting (then Chief Research Officer, Central Rainlands Research Station, Tozi) sent a collection of samples from the Sudan to Samaru. These samples and other introductions, together with local samples from the Nigerian survey, are being studied in a uniform nursery at Samaru as part of the preliminary assessment stage.

Other projects designed to complement this part of the program include a series of assay plots placed in each ecological zone. Each assay trial contains, in addition to its own local cultivar, representatives from each of the other zones. Another larger series of trials, containing standard "tester cultivars" is being carried out over a three year period. These trials give yield data but other observations are not as detailed as those in the Assay Plots.

It is hoped that the survey, together with this genecological approach will provide a sound basis for assessing the problems associated with sorghum improvement in the region. Future work on the survey will be concentrated on the relationships between Nigerian sorghums and their potential as breeding material. The Assay Plots and trials of "tester cultivars" should enable areas capable of growing the same improved strains to be delimited and should also indicate the sources from which the most promising basic material may be obtained.

Results so far have delimited four main areas. The second part of the program which is concerned with selection within local cultivars, has already started at four centers. Some of these strains have given yield increases up to 25%, and multiplication for distribution to the farmers will start with one strain in 1960.

So far, selection has been mainly based on yield with the rejection of lines which show obvious disadvantages such as lodging, poor quality grain and a heavy incidence of leaf and stem diseases. It is realized, however, that this preliminary selection from within local material is an interim measure, and studies connected with the long term program have been started.

Work in the pathology section (2) has been directed towards the identification of pathogens and their relative importance. A total of 55 fungi collected from sorghum includes at least 30 pathogenic species. The biology of some of these diseases is now being studied with particular emphasis on survival during the dry season and subsequent infection. Fungi attacking grain and those causing leaf spots have been studied in more detail. A description of a new species of Ramulispora causing leaf spotting is now in the press. The fungus is common in Nigeria and has been seen in herbarium collections from Haiti and East Pakistan as well as other parts of Africa. Recently "distortion", a condition of severe deformation and stunting, widespread on sorghum and other gramineae in Northern Nigeria, has been found to be caused by mealybugs and a preliminary study has been completed.

Entomological studies (3) on Sorghum midge (Contarinia sorghicola Coq) and on Agrotid stem borers of the genera Busseola and Sesamia have been in progress for the past five years. Entomological work (4) on grain storage has started recently.

Agronomic studies (5) include work on sorghum and its effect on subsequent crops in a rotation, fertilizer trials, and investigations on the semi-parasitic weed, Striga (Striga senegalensis Benth). Physiological studies on striga (6) are being carried out at the University College, Ibadan.

Work on the soil-crop-water relationship (7) of all crops including sorghum is being undertaken at Samaru, to investigate the reasons for the overall poor yields of the area and the general lack of response to fertilizers.

Use of rainfall, including its conservation and infiltration into the soil, forms a large part of this study. Cultivation treatments such as cross tying of the furrows and vertical mulching have been shown to affect root growth as well as plant growth and yield.

More recently, studies on the Sudan Dioch (8) (Quelea spp.) have been started at Samaru, and these will include observations on feeding habits in relation to different types of grain sorghum.

The results from the preliminary assessment will be extended to determine the factors responsible for the present localized distribution of cultivars. The duration of the rains appears to be the major factor which not only influences grain yield but also grain quality, especially in high rainfall areas. In the Sudan savanna and parts of the Northern Guinea savanna zones, where theoretically the potential prospects are highest, consideration is being given to new introductions and possibly the future production of hybrid seed. At present the organization of a hybrid seed producing scheme would present serious problems.

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Specialists engaged on sorghum studies in Nigeria

(1) Cereal sub-section D. L. Curtis and D. J. Andrews R.R.S. Samaru

(2) Harris, E. Pathologist R.R.S. Samaru

(3) Harris, K. Entomologist (Federal Agricultural Research Service stationed at R.R.S. Samaru)

(4) Giles, P. W. Entomologist R.R.S. Samaru

(5) Agronomy Section R.R.S. Samaru

(6) Williams, C. N. Research Fellow, Botany Dept. University College, IBADAN.

(7) Lawes, D. A. Physiologist, Empire Cotton Growing Corporation, stationed at R.R.S. Samaru

(8) Ward, P. Research Fellow, Zoology Dept. University College, IBADAN (stationed at R.R.S. Samaru)

Correspondence with specialists stationed at Samaru should be addressed to:

Secretary for Research & Specialist Services,
Ministry of Agriculture,
Samaru,
ZARIA,
Northern Region,
NIGERIA

and marked for the attention of the officer concerned.

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NOBLE FOUNDATION

Elbon Rye and Grain Sorghum

Roy A. Chessmore (Ardmore, Oklahoma)

Fertility studies in Oklahoma show that grain sorghums respond to heavy applications of fertilizers applied to a preceding cover crop of small grains and vetch. Elbon, a new variety of rye developed at the Noble Foundation at Ardmore, Oklahoma, has made this program even more satisfactory. It may be planted from

mid-September to mid-November and still produce winter cover and pasture. It will produce at least 50 percent more winter pasture than any other small grain available at the present time.

From 100 to 200 pounds of grain per acre may be obtained from Elbon rye and vetch by grazing with stocker calves, steers, or sheep. It has produced most of its growth by April 1, and the vetch may be plowed under in plenty of time for planting grain sorghum. The extra fertilizer, livestock manure, livestock urine, and the plant residues produce more reliable grain sorghum yields than heavy fertilization at planting time.

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NORTHERN RHODESIA

Sorghum Breeding in Northern Rhodesia

E. Mudenda (Chilanga)

Background

Sorghum is a subsistence crop in some areas of low fertility and in some areas of low rainfall where maize has not replaced sorghum. An increasing amount of grain sorghum is being used for making malt for the brewing of the "indigenous" type of beer in urban areas.

The breeding objectives, therefore, include selecting for high yielding qualities from a wide range of varieties and crossing a number of varieties in order to combine high yielding quality with malting quality.

Experimental work

The experimental station is situated on red clay soil at an altitude of 4000 feet. It has a mean annual rainfall of 32 inches which is distributed over a period of about 6 months.

A comparison of the yielding capacities of 360 local and introduced varieties has shown that the local varieties, which are invariably late maturing and adapted to high rainfall (40-54 inches) areas, give lower yields than most of the introduced varieties. The American bred dwarf sorghums, although comparatively low yielders, have proved their worth during short rainy seasons and in areas of low rainfall (16-30 inches). Varieties from Tanganyika have so far given the highest yields of up to 3100 pounds per acre with the aid of 200 lb/acre superphosphate and 200 lb/acre sulphate of ammonia. The yielding capacities of these varieties are being tested against those of American and South African hybrids.

K2 Red Kaffircorn, a South African variety which is popular with maltsters, has been crossed with a variety which has an open panicle, and varieties which are goose-necked in an effort to combine malting quality with resistance to bird damage. Observations on the F2 population in 1959 confirmed the report of workers in Tanganyika that when the bird population is unusually high, the "goose-neck" is not a reliable morphological feature for bird resistance.

Work on the evaluation of forage sorghum was begun last year and is being continued.

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OKLAHOMA and USDA

J. B. Sieglinger, D. E. Weibel, and F. F. Davies (Stillwater)

It is with deep regret that the death of Dr. R. P. Celarier, age 39, on December 23, 1959, from a heart attack is announced. Among his many contributions to the field of cytogenetics and cytotaxonomy of the grasses, he assembled a collection of several hundred accesions of Sorghum spp. from all over the world for studies of species relationships. A summary of the work was reported in the 1959 newsletter. Dr. J. G. J. de Wett has been employed to fill this position in the Botany and Plant Pathology Department at Oklahoma State University.

A season of unusually heavy precipitation in the fall months resulted in extreme weathering of grain at Stillwater. Yellow endosperm lines were especially susceptible, but virtually all the grain sorghums weathered badly. A search is underway for germ plasm that may help to overcome this production hazard.

Yield levels were good at most points in the state in 1959. At Woodward the average yield of the hybrid entries in the regional uniform yield nursery was 48.0 bushels per acre. At Stillwater the comparable average yield in bushels per acre was 55.8. Yield tests of other material produced well at Mangum, Erick, Goodwell (irrigated), and at Stratford.

Among F_1 plants from numerous crosses there were several involving an awned Ethiopian introduction brought to the United States by H. F. Murphy. The introduction was used as the pollen parent, and in every case the F_1 plants had strong awns. Previous reports indicate dominance of the awnless condition among American varieties (Sieglinger et.al. 1934). Laubsher (1945), however, has reported dominance of the awned condition in some African varieties.

Based on performance tests conducted at seven locations in Central and Western Oklahoma in 1957-59, four hybrid grain sorghums were added to the recommended list for 1960. These are: Amak R-10, Amak R-12, Pfister (P.A.G.) 515S and Pfister (P.A.G.) 425S.

Evaluation tests for grain hybrids and strains originating from Oklahoma's breeding program were initiated at four locations (Perkins, Mangum, Woodward, Goodwell) in 1959. Hybrids involving combinations of Redlan, Wheatland, Westland, Martin, Combine Kafir-60, and Dwarf Early Redlan steriles with yellow endosperm pollinators compared favorably in yield and adaptation with check hybrids (RS 610, Texas 660, DeKalb E56a). In 1960 these hybrids will be further evaluated in the state and will be included in the regional uniform observation nurseries in other states. Eleven yellow endosperm strains were included in these tests. Protein content of the grain from these strains was not different to that of non-yellow endosperm strain and varieties. Analyses of carotenoid pigments of these selections is in progress, and figures are not available at this time.

Frequency of Interspecific Crossing Between Sorghum vulgare and Sorghum halepense

J. R. Wilhite (Stillwater)

A study was conducted to test the frequency of interspecific crossing between Sorghum vulgare and Sorghum halepense. Six cytoplasmic male sterile lines of grain sorghum were used in the test. By using several different methods of pollination, 400 seeds were obtained. There appeared to be considerable differences among varieties in regard to seed set. The range of seed set was from 18 in Martin from Chillicothe, Texas, to 67 in Redlan from Oklahoma. From the 400 seeds obtained a random sample of 120 was drawn and planted in the greenhouse for a study of morphological characteristics. The principle characteristics studied were awned versus awnless, white dry midrib versus dull juicy midrib, rhizome development versus no rhizome development, and fertility versus sterility. At the present time a large number of the plants in the greenhouse are showing Johnsongrass characteristics including the development of rhizomes. A cytological study will be conducted as soon as material is available in an attempt to determine the chromosome numbers of these hybrids.

A Study of Quantitative Characters in Two Crosses of Sorghums

Tahir Ali Khan (Stillwater)

A study of hybrid vigor, heritabilities, and associations of ten quantitative characters was undertaken in two crosses of grain sorghum at Oklahoma State University during the summer of 1959. Four parents, Redlan x Plainsman (cross 1) and Combine Kafir-60 x Combine 7078 (cross 2) were grown with their F_1 hybrids and F_2 generations in a randomized complete block design with four replications. A total of sixty individual plants equally spaced at 18 inches were studied in parents and F_1 populations and 240 plants from respective F_2 populations. The significance of differences of various characters was tested by analysis of variance. Heritability estimates were obtained by F_2 variance method and association of characters were determined by calculating simple correlation coefficients.

In cross 1 hybrid vigor was exhibited in the following characters: Days to bloom (hybrid mean was 3 days earlier than the parents); head length; head weight; grain yield; number of seeds per plant; and protein content.

Hybrid vigor was evident in the F_1 generation of cross 2 in the following characters: Days to bloom; plant height; head length; head weight; grain yield; threshing percentage; weight of 100 seeds; number of seeds per plant; and bushel weight.

The highest estimates of heritability obtained were for plant height. These estimates were 49 and 73 percent in cross 1 and cross 2, respectively. The next most heritable character was blooming date in the two crosses with 40 and 51 percent heritability estimates. Grain yield in cross 1 was 32 percent heritable and in cross 2, 19 percent. Althought the heritability estimate for bushel weight in cross 1 was 11 percent, estimates for five other characters ranged from 16 to 41 percent.

Correlation coefficients for the two crosses were very similar for all characters studied. The following is a list of associated characters in order of correlation coefficients obtained:

Head weight and grain yield	(r = 0.9)
Grain yield and number of seeds per plant	(r = 0.7)
Head weight and number of seeds per plant	(r = 0.7)
Head weight and head length	(r = 0.4)
Grain yield and threshing percentage	(r = 0.4)
Grain yield and head length	(r = 0.3)
Weight of 100 seeds and bushel weight	(r = 0.3)
Number of seeds per plant and head length	(r = 0.2)

The Effects of Gibberellic Acid on Sorghum

Tahir Ali Khan

A study was undertaken to investigate the effects of G.A. on germination and preliminary growth of sorghums. Redlan and Sugar Drip varieties were used throughout the studies. Gibrel "88" from Merk and Company, a potassium salt form of G.A., was made into aqueous solutions of 1, 10, 100, 1000, and 10,000 p.p.m. concentrations. Responses were recorded at constant temperatures of 20° and 30° C., and under greenhouse, and field conditions. Observations were taken on emergence of seeds, rate of growth of radicals and plumules, and plant height.

Data on emergence of seeds does not thoroughly explain the stimulating effect of gibberellic acid. Growth measurements in Redlan indicated increased growth of radicals and plumules with the increasing G.A. concentrations. In Sugar Drip the response of radicals was the same as in Redlan, but increased growth of plumules with the increase in concentration was not recorded. Seedlings from treated seeds sown in the greenhouse and in the field showed temporary increases in height with increases in concentrations. Harmful effects of G.A. at 10,000 p.p.m., and in some cases at 1000 p.p.m., concentrations resulted in reduced germination and weak, abnormal plants.

Relative Value of Six Grain Sorghums (3 Hybrids and 3 Varieties) for Growing and Finishing Swine

J. C. Hillier et al. (Stillwater)*

Since many new grain sorghum hybrids have recently come into production, it seems desirable to test their characteristics as feed for swine with standard varieties. RS 610, Amak R-12, DeKalb F62a, Redlan, Kafir 44-14 and Darset were the hybrids and varieties chosen. This group was planted in one area at the Fort Reno Station, to supply the grain used in these tests.

Two types of tests were conducted: (1) a palatability test in which pigs were given a choice between the six entries of ground sorghum, and (2) a regular feeding trial in which replicate groups of pigs were fed the assigned entry of ground sorghum and supplement free-choice.

A summary of results showed: The hybrids and varieties used in these tests were not distinctly different from the standpoint of chemical analysis. A definite

*Also see Oklahoma Misc. Pub. MP-55, June, 1959.

preference was shown for RS 610 in the palatability tests. Kafir 44-14 appeared to be second most palatable, with Redlan and Amak R-12 distinctly less palatable.

In the feeding trials where the assigned entry of ground sorghum was fed free-choice with supplement, the rate of gains were not greatly different among treatments.

The pigs fed Darset, as the grain required about 29 pounds more feed per 100 pounds of gain than was required on the average for the other five varieties.

In terms of cost of producing pork, with Kafir 44-14 rate at 100 percent, the relative values of the other entries were: Amak 4-12, 99; Redlan, 99; RS 610, 95; Dekalb F62a, 95; and Darset, 87.

Sorghum Insect Studies in Oklahoma

C. F. Henderson, E. A. Wood, Jr., J. H. Hatchett and H. G. Kinzer (Stillwater)

The greatest amount of insect damage to sorghum was caused by the sorghum webworm. Populations of the chinch bug started off rather high, but these were reduced to a very low level by heavy rainfall occurring early in the growing season. The sorghum midge, corn flea beetle, corn leaf aphid and corn earworm were of minor importance during the year.

Insecticidal screening tests against the corn leaf aphid

Nine chemicals including Dibrom, Shell 3562, Dimethoate, Ethion, Carbon and Carbide Chemical 8305, malathion, phosdrin and American Cyanamid S-59 were tested against the corn leaf aphid in cage tests in the greenhouse. Parathion was used as a standard at the equivalent rate of 1/4 pound actual toxicant per acre. This material gave the best control (94%), followed by S-59 (90%), 3562 (90%) and Dibrom (88%). A very fast knockdown was achieved with Dibrom and Shell 3562. None of the materials showed any residual toxicity, with the possible exception of Dimethoate where populations decreased 50% after 7 days.

Control of the corn leaf aphid with granular insecticides

Thimet and Di-syston granules were applied at the rate of 1/2 pound actual toxicant per acre to sorghum heavily infested with corn leaf aphids in a greenhouse flat test. Both materials protected the plants after 5 reinfestations over a 5-week period.

Effectiveness of chemical control against the corn leaf aphid in sorghum whorls

Seventeen different chemicals were tested as emulsion sprays and 8 as granules. The best control percentages with emulsions were obtained by the following materials at the indicated dosages in pounds actual toxicant per acre (parenthesis): Thimet (.5) 86; Dimethoate (.5) 74; parathion (.5) 73; Shell 4402 (.25) 73; Thiodan (1.0) 72; demeton (.5) 70 and endrin (.3) 67. The best granules were Di-syston (.5) 98; Thimet (.5) 96; Shell 4402 (.25) 94 and Thiodan (1.0) 90. When the same chemicals were applied both as emulsions and granules, the latter formulations gave much more effective control.

Effect of nozzle position on control of corn leaf aphid in whorls

The lack of effectiveness of emulsion sprays against the corn leaf aphid in sorghum whorls was apparently partially due to the inability of the low-gallonage sprays to reach the inner portion of the whorls. This was indicated by the greater effectiveness of the granules which sifted down into the depth of the whorl. Further evidence was obtained in a test where emulsion sprays were applied with the nozzle pointed directly into the whorls at a 90° angle, as compared to treatment over the row at a 45° angle. Phosdrin spray applied by the former method at 0.5 pound toxicant per acre resulted in an average population of 5.8 aphids per whorl two days after treatment as compared with 9.2 for the latter. Sevin applied at 1.0 pound per acre in the same manner showed populations, respectively, of 10.9 and 19.0 aphids per whorl. There was an average population of 18.3 aphids per whorl in the checks.

Seed treatment for protection against the corn leaf aphid

Redlan sorghum and Ward barley were treated with Thimet and Di-syston at rates of 1/4 and 1/2 pound actual material per 100 pounds of seed. After emergence the plants were heavily infested with corn leaf aphids. One week after infesting, aphid counts were taken and the plants reinfested. Both materials gave excellent control over a 6-week period. Germination was not affected by either material.

Effectiveness of chemical control against the sorghum webworm

Eleven chemicals were tested against the sorghum webworm in sorghum heads. Excellent control was achieved with Sevin, phosdrin, Dibrom and Guthion. Parathion gave good control when applied at rates of 3/4 or more pounds per acre. DDT resulted in only fair control, and toxaphene, Dimethoate and Thiodan were unsatisfactory.

Effect of sorghum webworm on yield of sorghum grains

Phosdrin emulsion spray was applied at the following dosages in pounds actual toxicant per acre to sorghum in the heading stage infested with early instar larvae of the sorghum webworm: check, 0.032, 0.063, 0.125, 0.25 and 0.75. The following average number of larvae was found per head in single-row plots approximately one week after treatment at the respective dosage levels: 199, 56, 35, 17, 10 and 2; thus showing control percentages of 0, 72, 82, 92, 95 and 99. The average weight of the kernels in grams per head in the respective treatments was 2, 21, 35, 49, 64 and 59, or percentage losses in yield of 97, 64, 41, 17, 0 and 0. It is evident that no loss in yield occurred with dosages of 0.25 and 0.75 pound actual toxicant per acre and that approximately 200 larvae per head resulted in almost total loss of the crop.

Effectiveness of chemical control against the corn earworm in sorghum heads

As in previous tests conducted at this station, the chemical control tests against this insect resulted in unsatisfactory control. The best control was obtained with DDT, Sevin, phosdrin, Dibrom, toxaphene, and Shell 4402. The poorest control was with Thiodan, Dimethoate, Guthion and Phosphamidon. In one test in which the normal dosages were almost doubled, both DDT and Sevin gave fairly good control. In another test, pyrethrum was added to the DDT emulsion spray without any additional control being obtained. In most tests the larvae were from one-fourth to full grown. Mortalities were even unsatisfactory in a test where 66%

of the larvae were one-fourth grown. It is apparent that control of the corn earworm in sorghum heads is not feasible in this area with the presently available insecticides. Results in southern Texas have been quite similar.

Effectiveness of dieldrin spray for controlling the corn flea beetle on sorghum

During 1958, 17 different chemicals were tested against the corn flea beetle (Chaetocnema pulicaria) and dieldrin at 1/3 to 1/2 pound actual per acre was found to be the most effective. Consequently, when the flea beetle threatened young corn plantings this year, several fields were treated with dieldrin emulsion spray. The treatments were applied with a tractor-mounted boom sprayer at the rate of 1/2 pound actual toxicant in 11.2 gallons per acre. An untreated field was used as a check. Before treatment, populations averaged 2.53 beetles per plant in the check and 2.3, 5.1 and 4.0, respectively, in the 3 treated fields. Three days after treatment no beetles were found in the treated fields, as compared with 2.2 in the check. After 15 days there was an average of 1.8 beetles per plant in the check field, as compared with 0.06, 0.18 and 0.08 in the 3 treated fields. Thus, the percentages of control for the respective fields were 96, 95 and 97. These results substantiate the observations of the past year with regard to the effectiveness of dieldrin against this insect, although control was more satisfactory this season due to almost no reinfestation of the treated fields.

Effect of seed treatment on the corn flea beetle

On June 2, flea beetle counts were made in the various treatment and check plots (approximately 2 weeks after emergence of the sorghum plants). Because of the low populations present, six counts of 200 plants each were made in each plot. The numbers of beetles per 200-plant sample were as follows: Thimet (old) 7.3; Thimet (new) 8.7; Di-syston 13.7; and check 10.8. It is apparent that little, if any, control was afforded by the seed treatment. To further check the effectiveness of the various seed treatments against this insect, flea beetles were caged over individual plants taken at random. No control was indicated for any of the treatments, since fewer live bugs were found in the checks than in any of the treatments.

Effect of seed treatment on the stand of sorghum

Observations were made of the effect on the stand of sorghum of seed treatment with Thimet and Di-syston on activated carbon at the rate of 16 ounces of 50% material per 100 pounds of seed. Two lots of Thimet were used, one being an old sample labeled 3911 and the other a new shipment. Four rows of seed with each treatment including an untreated check were planted. The numbers of sorghum plants per foot of row 3 weeks after planting were as follows: Thimet (new) 2.74; Thimet (old) 2.34; Di-syston 2.45; and check 3.15. The percentages of reduction in stand for the three treatments were, respectively, 13, 26 and 22. This reduction in stand is probably due to decreased flowability of the treated seed.

Chinch bug control on sorghum

A test was conducted to determine the effectiveness of different chemicals and/or formulations for controlling the chinch bug on RS 610 sorghum. Four materials were applied as emulsion sprays with a portable compressed-air sprayer, and 6 as granular dusts with an applicator devised for this purpose. Counts taken 24 hours after treatment indicated the following percentages of control for emulsions

sprays applied at the indicated rate in pounds actual toxicant per acre: dieldrin 0.5, 95; endrin 0.33, 92; Dimethoate 0.5, 72; and Trithion 0.5, 52. The percentages of control for the granulated insecticides were as follows: Thimet 0.5, 96; dieldrin 0.5, 80; toxaphene 2.0, 76; endrin 0.33, 64; Di-syston 0.5, 40; and Trithion 0.5, 32. When the same chemicals were applied in emulsion and granular form, the emulsions usually gave the best control. After a heavy rainfall, which occurred 72 hours after treatment, populations of chinch bugs were reduced to such a low level that further counts were not feasible. A seed treatment test was also conducted in which Di-syston and Thimet on activated carbon were applied at 0.5 pound active ingredient per 100 pounds of seed. Four rows of each treatment, and of untreated seed, were planted with a 2-row planter. Counts in 10 plots receiving seed treatment indicated an average of 0.77 chinch bug per Hills sample, as compared with 0.65 for the adjacent check. It is apparent that the seed treatment had no significant effect on chinch bug populations.

Reaction of sorghum varieties and selecting to chinch bug attack

A total of 29 sorghum varieties and lines were screened for chinch bug resistance in greenhouse flat tests. Many of these same lines were planted in observation nurseries at the Perkins farm. In addition 11 yellow endosperm strains were screened in greenhouse flat tests. Eight varieties and two known susceptible checks were planted in each flat, with three replications for each variety. Ten days after planting each flat was infested with approximately 1000 immature chinch bugs. Injury ratings were taken periodically. The 4 most tolerant varieties were forage types. Tan Sumac showed the highest tolerance followed by Tan Sugar Drip, Sumac 1712 and Collier x-8-2. Of the grain sorghums tested Rice Kafir proved to be the most tolerant. This group was rescreened by infesting heavily at plant emergence, and with the exception of one Tan Sumac plant, all were injured beyond recovery. All of the yellow endosperm strains were found to be highly susceptible. It may be concluded that there is a great amount of difference in the reaction of sorghum varieties to chinch bug attack and that the time of infestation appears to be more of a factor in plant injury than does the intensity of infestation. The forage sorghums appear to have much more tolerance than the grain types.

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PAKISTAN

Breeding Tetraploid Grain Sorghums*

A. Ghafoor Bhatti (Sargodha)

Stebbins, in a review of the role of artificial polyploidy in plant breeding, said that the main cause of low fertility in induced tetraploids is genetically controlled physiological unbalance. Every species, through the course of its evolution, has attained a genetic balance, and any disturbance in this critically balanced system is likely to result in physiological disorder and sterility. Success of a tetraploid grain crop, therefore, hinges on the possibility of striking at a proper genetic balance, which in turn depends upon the diversity and size of the gene pool available.

*This work was done in the Genetics Department of the Agricultural and Mechanical College of Texas under the guidance of Drs. R. G. Reeves and John E. Endrizzi.

The second important factor in the fertility of the induced tetraploids is the harmony between the genes of the parental species. The cause of low fertility in a number of amphidiploids produced by doubling the chromosomes of the hybrids between distantly related species is explained by disharmonious interaction between genes of the parental species.

Meiotic irregularities and high frequency of multivalents also account for a part of the sterility in some of the induced polyploids. It appears, therefore, that the chances of success in breeding a tetraploid grain crop would depend upon the following conditions:

1. Availability of genetic diversity in the diploid species that can be crossed at the diploid or tetraploid level.
2. Harmony between the genes of the parental species.
3. Low frequency of multivalents and the absence of meiotic irregularities in the tetraploid.

Fortunately, Sorghum meets all of the above requirements, and there is large number of species and races in Sorghum that can be crossed readily and provide a wealth of genetic diversity that is rare in other farm crops.

Difficulty in inducing polyploidy in Sorghums by colchicine has, perhaps, been the chief obstacle in the development of tetraploids. Numerous attempts were made by several workers to induce polyploidy by colchicine, but except in a few cases, no permanent change in the chromosome number could be made.

During the course of a research project undertaken to ascertain the cytogenetic relationship between grain sorghum (Sorghum vulgare Pers.) and the Tunis grass, Sorghum virgatum (Hack) Stap. At College Station, Texas, several hundred young seedlings were treated with colchicine in the attempt to double the chromosome number of the F_1 hybrid between the two species for the study of chromosomal association at the tetraploid level. One percent colchicine was applied to the plumules of the young germinating seeds in lanolin paste. Most of the seedlings could not stand such a high concentration of colchicine and died. Out of the ten surviving plants the chromosomal complements of one plant were found to be doubled. This tetraploid S. vulgare-virgatum hybrid was fairly fertile (83% under greenhouse condition). The pollen from this tetraploid plant was used to pollinate male sterile diploid grain sorghum plants with a view to obtaining a tetraploid for the study of chromosomal behavior. From over six hundred stigmas pollinated only one seed was obtained which when planted yielded again a tetraploid instead of the expected triploid. Apparently this seed had resulted from the union of a normal gamete from the tetraploid with an unreduced egg of the diploid. The tetraploid plant which had three sets of chromosomes of Sorghum vulgare was not only highly fertile (93%) but had the grain size 15-25% larger than the parental diploid type. Cytological examination revealed 4-5 quadrivalents per cell at metaphase I with normal 20:20 segregation at anaphase. A fertility range from 5% to more than 95% was observed in the progeny of this plant, indicating a fair possibility of raising the fertility level by selection within the tetraploid progeny.

A high frequency of unreduced eggs has also been observed by several other sorghum geneticists in crosses between tetraploid and diploid species of Sorghum. It appears, therefore, that tetraploids with two sets of chromosomes of any of the existing varieties of sorghum can be easily obtained without the use of colchicine. All that is needed to be done is to pollinate large numbers of spikelets of the diploid type with the pollen from a tetraploid plant. The work can be facilitated

by using genetic or cytoplasmic male sterile stocks, but in cases where such stocks are not available hot water emasculation can be used. In case of hot water emasculation, however, larger number of spikelets have to be pollinated to get satisfactory results.

Tetraploid plants raised from the seeds obtained by the method suggested above can be easily recognized by their large seed size and fertility; the triploid on the other hand will, as a rule, be highly sterile. Thus, for large scale conversion of the diploid sorghums to tetraploids, all that is needed is a good tetraploid plant that has high pollen fertility. The tetraploid plant obtained by doubling the chromosome number of vulgare-virgatum hybrid has very high pollen fertility and can be used as a source of pollen for converting diploid sorghums to tetraploids.

By transforming diverse types of grain sorghums to tetraploids and making crosses among them, a huge gene pool with high genetic diversity can be made available, making the evolution of fertile tetraploids highly probable. The fertile tetraploids are not only expected to give higher yields than the diploid types, due to their large grain size, but the carotenoid contents are also expected to increase considerably. Since there is a strong numerical barrier between tetraploid and diploid sorghums, there is not great risk of accidental cross pollination, as is encountered in the tetraploid rye.

With the promising results obtained in this study and the relatively easier method of obtaining tetraploids, it seems that tetraploid sorghums offer a new approach to sorghum improvement.

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PENNSYLVANIA

Sorghum and Sudangrass in 1959

E. F. Sullivan and J. B. Washko (University Park)

Forage sorghum varietal tests

Several forage sorghum hybrids had favorable dry matter yields when compared to corn hybrids in southeastern (Landisville) and central (Centre Hall) Pennsylvania. Pa. 602 corn hybrid was more productive of forage than sorgos at the Central location. Dry weather during May through July decreased the average dry matter yields of sorgo and corn by 1.48 tons per acre at Landisville. Under these conditions, Asgrow Silo King sorgo had highest yields. Several sorgos produced tillers at culm nodes as a consequence of dry weather. This condition was most characteristic with RS 301F sorgo. Black Amber sorgo was inferior in yield to the hybrid NK 145; however, this hybrid gave lower yields than Pa. 444 corn hybrid at both locations (Table 1).

The estimated feeding value was slightly higher for corn at both locations. The forage produced at Landisville had slightly higher quality than that at Centre Hall. Sorgo hybrids gave higher yields and feeding values than sorgo varieties (Table 1).

Grass sorghum varietal tests

This uniform test was grown cooperatively with the U.S.D.A. at two locations. Pearl millet was included in each test. Texas experimentals A 3054-20 x R 3061, A 3056-15 x R 3061, and A 3056-17 x R 3061 were productive averaging 5.04 tons of dry matter per acre. Piper sudangrass averaged 4.14 tons, and Tift sudangrass 4.59 tons of dry matter per acre. Other grass sorghums were equally productive. The sorgrasses Perennial Sweet and Sorghum almum had 4.15 and 4.55 tons of dry matter per acre, respectively. Sorgrasses which cannot be identified from Johnsongrass are considered noxious weeds in Pennsylvania. Pearl millet yields were inferior to grass sorghum yields. The feeding values of forage as determined by proximate analysis were good; however, differences occurred between locations and among entries for this variable. This was due to stage of maturity and time of cut (Table 2).

Piper sudangrass had less resistance to foliage diseases than Tift, Greenleaf, Ga. 337, and other grass sorghums.

Forage sorghum culture test

A pilot study was conducted at Centre Hall to determine the effect of row spacings on the yield of forage. The results were: 40 in., 6.79 tons; 21 in., 7.08 tons; and 7 in., 9.21 tons of dry matter per acre. RS 301F sorgo produced 10.07 tons, and Pa. 602 corn had 8.56 tons per acre at the 7 in. row spacing. Plant lodging increased with close planting. Plant population was estimated at 52.3 M and 19.6 M per acre at the 40 in. spacing for sorgo and corn, respectively. The 7 and 21 in. treatments had populations proportionally higher.

Forage sorghum fertilizer experiments

Two types of fertilizer experiments were conducted in 1959; (1) row plantings and (2) drill plantings comparing hybrid corn, forage sorghums, Gahi millet and Piper sudangrass. Rows were 38 inches apart in planting experiments and 7 inches apart in the drill plantings.

The wide row experiments were conducted at three locations in the state, namely, Hershey (SE)University Park (Central) and Milan (Northern). In these experiments the corn hybrids were planted at 20,000 plants per acre, the sorghum at 50,000 and the millet and sudangrass at 6 pounds of seed per acre. The equivalent of 500 pounds of 0-20-20 fertilizer was applied per acre at each location prior to seeding and nitrogen at rates of 50, 100 and 200 pounds per acre.

The 7-inch row plots were seeded with a grain drill. Prior to drilling, fertilizer was applied and disked. In both types of experiments the various species were harvested at the silage stage and were evaluated in terms of yield, T.D.N. production and crude protein content.

The corn hybrids were most productive of forage and T.D.N. of all species. Pa. 602 tall hybrid was more productive than its counterpart dwarf 602. Hybrid sorghum RS 301 was next most productive, followed in turn by Gahi Millet and Piper sudangrass in that order (Table 3).

In the wide-row experiments the influence of nitrogen fertilization on forage production of the various species was variable and minor. Differences between nitrogen rates were statistically non-significant in these experiments. Both the

hybrid corn and hybrid forage sorghum responded to nitrogen fertilization in the grain drilled plots. The influence of N on forage production of Gahi Millet and Piper sudangrass in the latter plots, however, was not pronounced.

Different P and K levels failed to influence materially forage production of the four summer annuals grown in the drilled experiment. Somewhat higher forage yields were obtained when P and K were used in the ratio of 1 to 2 rather than 1 to 1 in conjunction with nitrogen, but the yield differences were not statistically significant. In fact, 50 lbs. per acre of P_2O_5 and 100 lbs. per acre of K_2O produced yields that were as high as those obtained with 200 lbs. per acre of each of these plant nutrients.

Lodging was a serious problem in the drill plantings but was not in the row plantings. RS 301F forage sorghum, in particular, appeared to be more susceptible to lodging than the other species in the thick drill planting.

Table 1. 1959 Sorghum adaptation test results at two locations in Pennsylvania (av. of 4 replications per location).

Hybrid or Variety	Central Pa. - Centre Hall				Southeastern Pa. - Landisville			
	Dry matter	T.D.N.	Meta. energy	Dig. protein	Dry matter	T.D.N.	Meta. energy	Dig. protein
	tons/A	%	cal/kg	%	tons/A	%	cal/kg	%
Asgrow Silo King	6.09	65.9	2347	4.1	5.58	72.7	2592	7.4
Atlas*	5.70	63.4	2261	3.4	3.48	64.4	2294	6.9
Black Amber*	3.30	64.1	2286	4.9	2.76	61.8	2204	5.4
DeKalb FS-1a	6.75	67.1	2390	5.6	4.24	68.4	2436	6.8
Frontier S-210	5.78	65.6	2338	3.8	3.53	66.1	2356	6.4
Ill. 6021 corn	--	--	--	--	4.77	74.5	2655	8.2
Ill. 6052 corn	--	--	--	--	4.38	70.0	2496	7.6
NK 145	4.03	59.5	2119	5.2	2.83	57.2	2037	4.9
NK 3065	5.57	71.6	2553	6.1	4.60	70.3	2504	7.9
Pa. 444 corn	5.06	65.5	2333	4.7	3.51	68.0	2422	6.1
Pa. 602 corn	6.83	69.1	2461	5.3	3.60	63.2	2251	5.0
RS 301F	5.37	63.7	2269	3.6	4.39	68.1	2428	6.4
L.S.D. .05	0.93				0.69			
C.V.%	12.5				12.4			

*Recommended in Pennsylvania. Seeding dates - May 26, Central; and May 15, Southeast.

Table 2. 1959 Grass sorghum adaptation test results at two locations in Pennsylvania (av. of 4 replications per location).

Hybrid or Variety	Central Pa. - Centre Hall				Southeastern Pa. - Landisville			
	Dry matter	T.D.N.	Meta. energy	Dig. protein	Dry matter	T.D.N.	Meta. energy	Dig. protein
	tons/A	%	cal/kg	%	tons/A	%	cal/kg	%
Ga. 337 sudan	4.61	62.0	2209	11.3	4.64	62.8	2238	8.9
Greenleaf sudan	3.83	57.2	2038	9.4	4.84	63.2	2253	10.4
Piper sudan*	3.44	58.0	2067	8.5	4.84	62.2	2216	10.4
SX-11 sudan	4.97	60.4	2151	11.0	4.41	62.8	2239	8.5
Tift sudan	4.08	58.6	2090	9.7	5.11	62.3	2220	9.6
Texas 15 x sudan	4.26	56.4	2010	9.9	5.94	61.9	2205	7.7
Gahi pearl	3.99	61.3	2185	13.1	3.53	64.0	2281	8.8
Selection 7 pearl	3.69	59.2	2110	10.4	3.91	63.4	2259	8.8
Starr pearl	3.45	63.4	2261	11.6	3.57	62.2	2217	6.7
L.S.D. .05	0.51				0.62			
C.V.%	8.9				9.6			

*Recommended in Pennsylvania. Composition data from first cut at Centre Hall (July 23) and third cut at Landisville (September 22) from seedings made on May 25 and May 15, respectively. Drilled in 1 ft. spacings at 30 lbs. (sudangrass) and 25 lbs. (millet) of viable seed per acre.

Table 3. Influence of nitrogen fertilization of annual forage crops at three locations in Pennsylvania, 1959.

Variety and species	Nitrogen applied - pounds per acre								
	50	100	200	50	100	200	50	100	200
	Dry matter-tons/acre			T.D.N.-tons/acre			% Crude protein		
*Pa. hybrid corn	5.62	5.65	5.16	3.66	3.82	3.20	10.5	10.8	9.6
Dwarf 602 corn	3.98	4.04	4.25	2.69	2.75	2.95	12.0	11.0	11.8
RS 301F hybrid sorghum	3.53	3.75	3.54	2.19	2.34	2.14	10.0	9.8	9.8
**Black Amber sorghum	3.29	2.71	2.67	1.94	1.62	1.61	9.5	8.8	9.0
Gahi millet	4.91	4.94	4.81	2.63	2.66	2.68	11.6	11.6	13.5
Piper sudangrass	3.30	3.51	3.42	1.85	1.97	1.94	11.2	11.6	12.3

* Pa. hybrid 602 was used except in Northern Pa. where the shorter season Pa. 444 was planted.
**Not seeded in Southeast Pa.

Growth Chamber Study

E. F. Sullivan, C. L. Rhykerd and C. F. Gross

This cooperative study was conducted at the U.S. Pasture Laboratory to determine more critically the minimum and optimum temperature requirements for seedling growth of three sorghums (Piper sudangrass, RS 501 grain sorghum and FS-1a forage sorghum). Constant temperatures of 60, 70, 80 and 90° F. were used with P_2O_5 fertilization rates of 0, 50, 100, 200 and 400 lbs. per acre. The growth period, under 1000 f.c. of artificial light 15½ hours each day, was 6 weeks. Results indicated that the growth rate of Piper sudangrass and RS 501 grain sorghum was most rapid at 80° F. FS-1a produced higher top and root weights at a constant air temperature of 90° F. No growth responses to P_2O_5 fertilizer occurred at 60° F. At 70° F. and above, P_2O_5 fertilizer gave significant increases in the growth rate of sorghum. In addition, significant interactions were observed. The dry matter of the tops of Piper sudangrass was analyzed for P, N, and lignin.

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PIONEER HI-BRED CORN COMPANY

Harold J. Kidd (Plainview, Tex.)

Sorghum breeding

Our organization is doing sorghum breeding and research at three locations: Johnston, Iowa; York, Nebraska, and Plainview, Texas. Aside from breeding work, the observations listed below may be of general interest.

An F_1 hybrid at Plainview, Texas, between Sundhia S1049 (an introduction from India, fairly early, tall fine-stemmed) and what appears to be an Amber type from Germany, labelled Sorghum saccharatum, set no seed when selfed, and ten percent or less when open-pollinated. The nature of this sterility is not known. Sundhia has not been checked cytologically and could possibly be tetraploid. Its morphology does not resemble S. halepense, however. Seed-set in Sundhia is very good as a variety, and would be unusual in a tetraploid. Studies are continuing on this matter.

Preliminary report of studies of the genetics of restoration of cytoplasmic male sterility in sorghum

The following lines were used as parents:
Caprock SA 7000, restorer of fertility.
26-1 ms, a cytoplasmic male sterile developed by Pioneer Hi-Bred Corn Co.
Martin ms, a cytoplasmic male sterile.
Combine Kafir-60 ms, SA 3197, a cytoplasmic male sterile.
The three named varieties will be abbreviated in this report as follows:
Caprock, Cap.; Martin, Mar.; Combine Kafir 60, CK60.

The following crosses and their parents were studied:
26-1 ms x Cap., the F_1, F_2, and BC_1 (to 26-1) populations.
Mar. ms x Cap., the F_1, and 26-1 x (Mar. x Cap.).
CK60 ms x Cap., the F_1, and Mar. x (CK60 x Cap.).

The preceding populations were grown at three locations, Plainview, Texas; York, Nebraska; and Johnston, Iowa. All segregating populations were classified in their entirety, using the appearance of their anthers in the following manner:

Class 1. Completely sterile. Anthers very poorly formed, hardly at all flattened, and a uniformly light brown color when dry. Fresh anthers are considerably lighter yellow than those carrying pollen.

Class 2. Nearly sterile. General appearance of anthers is very much as in class 1, except that they are somewhat broader and flattened and almost always develop dark brown spots. These spots are considerably darker than a normal dry anther, and are observable for two or three days after drying. The yellow color of the non-darkened part of the anther is about the same as in class 1.

Class 3. Intermediate. These anthers are plumper than class 2 but are still poorer than those which are shedding significant amounts of pollen. One good index is the relatively sharp point at the apex of the anther. Flattening is less severe than in class 2, but is still observable. Frequently brown spotting is more severe than in class 2.

Class 4. Nearly fertile. The anthers are more plump than in class 3, pores may be seen, and observable amounts of pollen may be seen when anthers are shedding, but not in large quantities as in normal panicles. Brown spotting is greatly reduced but usually present. Anthers are still slightly more pointed than normal.

Class 5. Fully fertile. Anthers are plump, bright yellow, and a shedding panicle will give a cloud of pollen when tapped. Pores are readily seen with unaided normal vision, and brown spotting is almost never seen. Anthers are a light buff color upon drying, except for an occassional obvious deformed anther.

The data from this classification method have proved to yield comparable results from several persons.

In 1959, Plainview populations were more fertile than York, which were more fertile than Johnston. At Johnston, none of the F_1 hybrids was scored fully fertile, 26-1 x Cap. and Mar. x Cap. ranging from classes 3-5, and CK60 x Cap., from 1-4. At York, CK60 x Cap. was scored classes 4 and 5. All F_1 hybrids at Plainview and the remaining two at York were scored fully fertile.

Ratios obtained ranged from one gene to four, with four-gene ratios predominating. Likewise, as would be expected, the ratios suggest an explanation based on a single major gene and several modifiers. The variation in ratios is interpreted as indicating that, in certain crosses at certain locations, varying numbers of genes were required for the degree of restoration obtained.

Studies on fertility restoration are continuing, with plans to repeat with populations using Caprock as the restorer, and adding the variety Day as another, and possibly some intermediate, such as Westland.

Parenthetically, in 1959, near Manhattan, Kansas, a similar study was made of an F_2 population of RS 610 (Combine Kafir-60 x SA 7078), and two-gene ratios were obtained. Since about half of the "class 3" panicles set one or more seeds we had a means of comparing with the studies of Maunder and Pickett at Lafayette, Indiana, which were based upon seed-set. When classes 1 and 2 were combined with one-half of the class three's, a 3:1 ratio resulted.

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ROCKEFELLER FOUNDATION

Sorghum Research in Mexico

J. M. Munoz, R. D. Osler, and E. C. Johnson (Mexico City)

Effect of harvest date on yields of sorghum

During the summer of 1959, six different varieties of forage sorghum were planted in a split plot design. They were harvested at thirteen-day intervals on four different dates. The first date of harvest was the end of flowering, and the last date of harvest was when the grain was mature.

All the varieties, as an average, attained their maximum yield of green forage by the end of flowering. They remained at approximately the same yield during the milk and dough stages of the grain, but declined when the crop advanced into the mature-grain stage.

Regardless of the changes observed in the yields of green forage, the amounts of dry-matter continued to increase until the dough stage of the grain. A loss of dry-matter was observed as ripening of the leaves occurred.

Water content of the forage decreased from the end of flowering until the hard-grain stage.

There was a highly significant difference in yield between varieties and between dates of harvest. Sumac and Honey were the highest yielding varieties and the dough stage of the grain gave the largest yields.

Optimum plot size for sorgos and broomcorns

A study was initiated in 1959 to determine the optimum plot size for forage sorghums and broomcorns. This study, which included six varieties of each type, were planted in separate experiments, and harvested at four different dates after flowering. These data are now being analyzed by the different methods proposed to determine optimum plot size.

This study is being continued in 1960, adding an experiment with grain sorghums

The hybrids of grain sorghums

A number of open pedigree hybrids have been tested in comparative yield trials in most of the potentially important sorghum producing areas in Mexico. Their yield rarely differs significantly from the adapted varieties. An intensive program is being conducted searching for hybrid combinations best adapted to Mexico. Meanwhile, two hybrids, Texas 620 and RS 610, are being produced and recommended by a federal government seed production agency.

Some Observations on Sorghums in Africa

K. O. Rachie (New Delhi, India)

The observations reported were made during a tour of Africa to study sorghum and millet cultivation, use, and improvement, and to collect information and materials for use in India. The tour began on November 16 and ended December 23, 1959. Nine countries were visited: Kenya, Uganda, Union of South Africa, Southern Rhodesia, Belgian Congo, Ghana, Nigeria, Sudan, and Ethiopia.

Kenya and Uganda

Sorghums are grown annually on about 400,000 acres in Kenya. Most of the important agricultural lands, ranging from 5000 to 9000 feet elevation, are considered too high for sorghums, and in these regions wheat and maize are the principal cereal crops. Natives still grow some sorghum and millets at lower and drier elevations, but maize is coming into vogue owing to its being preferred for human food and because of the bird problem. Bird attacks in this region have been so heavy that the Katumani Experiment Station at Machakos (44 miles east of Nairobi) has abandoned efforts on sorghums and pearl millet and is concentrating on early maize.

Sorghums and millets (primarily Pennisetum typhoides) are much more important in Uganda and Tanganyika, where most of the agricultural lands are at lower elevations (2500 - 4000 feet). About 680,000 acres are grown annually in Uganda and 100,000 in Tanganyika. The major problem in these countries is birds, but stalk borers of Chilo and Sesamia spp. and the shoot fly, Atherigonia indica, are also very important pests.

In Uganda, which is near the equator, the rainfall is distributed bimodally. There are two cropping seasons which correspond to the periods of heaviest rainfall--March-June, the more important, and October-December. Native methods of growing sorghum include plowing and broadcasting the seed at a heavy rate. Stands are naturally thinned by insects, diseases, or birds, but sometimes the young standing crop may also be plowed to thin the stand and help kill some weeds. If new lands are broken, it is necessary to burn before plowing to destroy the heavy growth of grass and bush. The dominant grass species is Hyparrhenia, which is very palatable in the early growth period but later becomes very coarse.

The Serere Experiment Station in eastern Uganda has an extensive sorghum breeding program under the leadership of Mr. Hugh H. Doggett. Mr. Doggett recently moved to Serere from Tanganyika where he had worked for about 11 years. His principal problems are birds, the most serious of which is the quelea, a small, gregarious, migrating type. Weaver birds, parrots, finches, and other birds are also important. Local methods of reducing bird damage include the use of scarecrows, noisemakers, bird chasers, and globs of sticky bird lime (made from fig tree exudates) affixed to the tops of the taller sorghum plants. Children used to be assigned to the task of birdscaring, but in recent years they have been increasingly diverted to schools in the expanding educational system. It has, therefore, become more difficult and expensive to grow sorghums. Mr. Doggett has made an effort to breed for bird resistance. Long glumes and long awns are being incorporated into desirable types. Other characters under observation that are reputed to help against birds are goosenecking, large flag leaf partially covering poorly exserted earheads, open earheads with long panicle branches, and bitter grains. Goosenecking

may help by providing an upside-down perch, a situation many birds do not like because of its awkwardness and the fact that it affords them less opportunity to watch for their enemies. It had been noted that in general only the upper (or base) third of goosenecked varieties were taken by birds. Some varieties, like Korgi, develop several tillers which grow at an angle of about 60° to the horizontal, have ears that bend downward slightly, and produce large flag leaves that obstruct the birds' view. Undoubtedly incomplete exsertion from the flag sheath has helped many varieties survive attacks by birds and other animals.

Improved and local varieties have spreading heads with relatively long panicle branches borne on a protracted rachis and bearing reddish-brown, bitter grains in clusters. Such types are less affected by head insects and birds. The cluster-seeded character probably has a higher grain-yielding potential than the normal spreading-panicle character.

Most of the sorghums in East and South Africa are used for making native beer, but it may be possible to remove the bitter, colored seedcoat by polishing or pearling - as for rice or barley - and to use them directly for human food. It would be necessary to have varieties with a fair proportion of hard corneous starch, since soft starch types tend to disintegrate in the pearling operation. Corneous types are generally preferred for food and have a greater resistance to grain storage pests. When mature, these varieties are also more resistant to birds.

Studies had been carried out on the resistance of several varieties to stored grain pests. All varieties were eventually attacked by these pests to a greater or lesser degree, but the development of infestation was much slower in corneous types. In making these studies, Mr. Doggett used loosely woven cloth bags containing a determined number of seeds which were buried in infested grain for varying periods.

The most prevalent wild sorghum species in Uganda is S. verticilliflorum, but S. purpureo sericeum is also found. S. halepense has not been introduced or has failed to thrive.

Sorghum is grown primarily for grain. As there are vast grazing lands available, there is little need for fodder, and consequently very little attention has been given to fodder quality and quantity in the sorghum improvement program. Most of the local or improved varieties are pithy-stalked and rather short, ranging from 3-1/2 to 5 feet in height.

Native beer is prepared by soaking sorghum grain in water for three or four days until the grain has germinated and produced a short coleoptile about 1/4 inch long. The soaked grain is then partially dried and transferred to a basket where it is mixed with wood ashes and kept moist. After about 30 days it is dried, mixed with a small amount of similarly treated finger millet grain, and ground on a flat stone. The millet grain reportedly provides some essential ingredient such as yeast cells, flavor, or other quality to the beer. After grinding, the coarse flour is mixed with water and fermented for four days. The fermented beer is kept in gourds to which hot water is added just before drinking. The liquid is sucked from the gourds by means of a long straw.

Utilization of hybrids in East Africa does not appear to be a likely possibility in the near future, since native farmers cannot afford to invest in better seeds or other improvement measures. Greatest attention has been given to improvement of local types. The possibility of developing synthetics through use of

genetic steriles and the potentials of allotetraploids are under study. The main drawback of tetraploids is lowered fertility. Early studies indicate that fertility may be selected for in these types. Another approach is to develop tetraploids from twin or triple seeded varieties, thereby increasing the number of florets per spikelet bearing at least one kernel.

The plant parasite of Striga spp. or witchweed (particularly S. asiatica) is an important problem in some areas. Several varieties of sorghum have shown resistance including Dobbs, Dwarf White Milo, and Dwarf Yellow Milo. Resistance has been found somewhat unstable owing perhaps to environmental conditions or genetic changes in the parasite.

Union of South Africa

South Africa produces about 400 million pounds of sorghums on 700,000 to 1,000,000 acres. Most of this acreage is in the eastern half of the country. Certain areas just north of and within northern Orange Free State are the highest producing regions for maize and sorghum. About 90% or more of this sorghum is used for making native or kafir beer. Maize is the principal cereal for human consumption.

The kafir beer-making industry has recently been taken over by the government, and local or native brewing is outlawed. Malting is carried out by private enterprise. Bitter-grained, bird-resistant varieties, such as Radar and Birdproof, are preferred for this purpose. The grain is sold on the basis of grade. In the malting process, the grain is steeped or soaked in water for 12 to 24 hours (depending on temperatures); it is then transferred to concrete floors for four to ten days, where it is kept covered by wetted burlap until proper germination and malting has been attained, after which it is dried in the sun and ground. The malt is sold on the basis of diastatic power. Government breweries buy the malt and ferment the brew. Brewing requires about three days. Three and a half 200-pound bags of malt are mixed with five bags of ground grain (maize, sorghum, etc.) to make 1400 gallons of light grayish brew. The beer contains 3% alcohol and is considered to be very rich in vitamins, minerals, and carbohydrates. It is recommended for invalid and geriatrics patients.

Southern Rhodesia

At the Matopos Experiment Station, 15 miles south of Bulawayo, some interesting experiments on sorghum populations are under way. Seeding rates up to 50 pounds per acre have been tried in 18- and 36-inch rows. The highest seeding rates using 18-inch rows, although developing the smallest plants and earheads, have produced the highest yields. Varieties grown in these trials are of limited maturity and height. Sorghums perform best on the heavy, black soils; maize yields best on the medium red soils; and pearl millet excels on the light, sandy soils of this station.

Belgian Congo

Principal food crops of the Congo and nearby countries are cassava, yams, bananas, maize, sorghum, and millet. Sorghum and millets are grown chiefly in the eastern (in Ruanda-Urundi) and southern parts of the country. About 75% of the total sorghum-millets production is sorghum. The production of these crops and maize in the Congo and nearby countries for 1958 is as follows:

	Sorghum and Millet		Maize	
	Area (1000 acres)	Production (1000 tons)	Area (1000 acres)	Production (1000 tons)
Belgian Congo	711	315	1,186	578
French Cameroons	1,032	412	321	137
French Equatorial Africa	4,051	336	99	45
Angola	--	--	1,482	358
Total	5,794	1,063	3,088	1,118

An extensive and complete agricultural research institute has been established in the heart of the Congo jungle at Yangambi, about 1000 miles from the coast. This institution carries out investigations on several food crops, but the work on sorghum is done at Rubona in Ruanda-Urundi. The work on pearl and finger millets is conducted at Kiyaka in the southeast and Keyberg in the southwest of the Congo.

A wild species of sorghum, S. arundinaceum, has introgressed from East Africa and is widespread in the Yangambi area. In some regions S. caudatum is also found. The latter was probably a cultivated species introduced by early Arab traders.

Ghana and Nigeria

Principal foods in these countries are pearl millet, sorghum, maize, bananas, yams, and cassava. It is estimated that sorghums make up 50% of the diet. Cassava and bananas are produced mainly in the more humid, southern coastal regions; millets, sorghum, and maize, in the central and northern regions. There is considerable internal movement of these products. Yams, millet, sorghum, and groundnuts move south, and maize, bananas, and cassava move north. Cropping consists of burning and clearing patches of land which average about 4 acres per family. The land is cultivated for three to five years, after which the soil fertility is depleted and a new patch is cleared. The most common rotation consists of yams for two seasons, followed by sorghum, millet, and peanuts.

The principal sorghum of northern Nigeria is a late maturing, yellow-grained variety called Kaura. Its earhead is among the most beautiful seen in sorghum. Heads are semi-compact to open, and a foot or more in length. The grain is large, deep yellow in color, and has hard corneous starch. The bright yellow (yellow endosperm) grain color is retained in spite of maturing in the open. Kaura has 26-32 leaves and requires six months to mature.

The Samaru Experiment Station near Zaria, about 50 miles south of Kano, Northern Nigeria, is undertaking work in several phases of sorghum improvement. About 750 collections were made throughout Nigeria. Most of these collections fall into the sub-species of S. guineense, S. caffra, S. caffrorum, and S. arundinaceum. An attempt is being made to classify this collection according to ecological criteria. The main difficulty is that several of the characters studied for this purpose are relatively simple inherited and wide crossing among types has occurred. Dr. W. R. Stanton is in charge of plant breeding, and Mr. D. L. Curtis and Mr. D. Andrews have specific responsibilities regarding the improvement of sorghums and maize.

Sorghum diseases and insect pests have received special attention at Zaria. The important leaf diseases are the bacterial leaf spots, ascochyta, cercospora,

and helminthosporium. Sphacelia sorghi (sugary disease) is also important and is being studied. One of the workers had cultured this organism until the sclerotial stage, or ergot, had developed. Usually this pathogen does not develop ergot bodies, such as are found in rye, because the organism is parasitized by a fungus before the sclerotial stage is reached.

Important insect pests include the midge, Contarinia sorghicola, and stalk borers of the Bassiola and Sesamia spp. Against the midge, DDT sprays at flowering time have been found effective. Long glume varieties that do not open during anthesis may also be effective against this pest. Endrin sprays have proved most effective against borers when applied two and four weeks after planting. Clean cultivation and destroying crop residues on a regional basis are recommended.

A full-time ornithologist has been assigned at Samaru to study the bird problems. The most important birds are the quelea, weaver birds, and finches. Habits of these birds are studied in the natural state as well as in captivity. One control measure against the quelea involves blasting their nesting sites with drums of gasoline. This method is not effective, however, unless carried out over a large territory. Scaring birds and the use of frightening devices have proved ineffective. Even bird-resistant varieties are attacked if bird populations are large enough.

Sorghum production in Nigeria is estimated at 1,195,000 tons grown on about 6,500,000 acres. Plantings are made in July and harvested in December. The common practice is to plant in hills 18 inches apart, leaving two plants per hill with 36-inch rows. Higher populations than this depress the yields because they do not permit the full development of the tall, late varieties grown. Land is prepared and ridged up for planting by hand.

Sudan and Ethiopia

In the Sudan, sorghum is grown on about half of the acreage and is, by a considerable margin, the country's most important cereal. In 1956-57 sorghum was grown on 2,491,501 acres and produced 1,076,344 tons of grain. East-central Sudan is the principal region for sorghum and pearl millet production. Sorghums are grown on the heavier soils, and pearl millet on the lighter, sandy soils. For human consumption pearl millet is preferred to sorghum and brings a higher price on the market. The white, hard-grained sorghums are preferred over soft or colored grain types, such as the feteritas.

Sorghums are widely grown throughout Ethiopia, even at elevations up to 8000 feet or higher. Under these high altitude conditions, plant growth is very slow and seven to ten months are required for maturity. Recently Mr. E. G. Damon of the ICA Oklahoma Contract group stationed at Jimma reported on a variety found growing at an elevation of slightly above 9000 feet. It was similar to other high-elevation types which are called "anchero." These varieties tend to be tall, with loose, spreading heads, and they bear medium size grains, pearly white, red, or brown in color. At lower elevations the compact headed varieties predominate. Among the 150 sorghums collected in Ethiopia by Mr. Damon were a number of interesting species, including a thick-stalked, late-maturing, dwarf variety. This variety has open, spreading heads that do not exsert well and have large flag leaves. The effect of poor exsertion and prominent upper and flag leaves is to partially obscure the earheads from view, a characteristic that may be helpful against birds. A variety collected at Jimma is tolerant of poorly drained soils and was the only survivor of several other Ethiopian and exotic varieties planted on a poorly drained plot at the Jimma Agricultural College farm.

Sorghum and other crops are usually planted thickly by broadcasting following plowing. Seeds are covered by replowing, harrowing, or trampling by livestock. During the early growth period, cultivation may be carried out by plowing indiscriminately through the field. This thins the stand and removes some weeds, but tends to injure roots.

The farmers in some regions strip the leaves from the maturing sorghum crop for use as fodder. The remaining stalks are tied together in the top for support while the large compact heads mature.

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SOUTH CAROLINA

Sorghum and Sudangrass Breeding and Variety Testing in South Carolina

E. F. McClain (Clemson)

Grain sorghum variety performance trials are being conducted under the supervision of E. B. Eskew at Clemson and under A. Manwiller at the Pee Dee station. Dr. Manwiller also has a grain sorghum breeding program underway. Open-head types are emphasized in both breeding and testing.

U.S.D.A. regional sorgo variety performance trials are also conducted at the Edisto station with the assistance of R. F. Suman and at Clemson with the assistance of E. B. Eskew.

Forage sorghum and sudangrass breeding and variety testing programs are conducted at Clemson and the branch experiment stations under the supervision of E. F. McClain. Several F_1 hybrids between forage sorghum or sorgo varieties, sudangrass varieties, and sorghum and sudangrass have been experimentally produced with the aid of hot-water emasculation. Some crosses exhibited considerable potential. F_1 hybrids produced by crossing more than 200 sorghum and sudangrass varieties and foreign introductions with cytoplasmic male-sterile Combine Kafir-60 were observed in 1959. No outstanding combinations were exhibited. However, a few appeared to merit further testing. Conversion of a few sorghum varieties to double-dwarf, male-sterile types is in progress and the development of c.m.s. sudangrass lines is being attempted. Sorghum and sudangrass non-restorer populations in fertile cytoplasm are also being developed to be used with restorer populations in reciprocal recurrent selection programs. The development of the male-sterile parents of selected combinations should thus be simplified.

The DeKalb hybrid and SX-11 sudangrasses have yielded more than any of the 14 varieties tested at Clemson during the past 3 years and have shown good resistance to foliar diseases. No sudangrass variety or hybrid has yet equalled the yield of Gahi-1 pearl millet at this station. Ga. 337, Stoneville Selection, and Stoneville Synthetic sudangrass varieties have exhibited the best foliar disease resistance.

Sorghum almum and Perennial Sweet sudangrass produced the highest yields of six perennial sorghums tested in 1958 at Clemson. However, Mississippi Persistent johnsongrass and the SJ2 hybrid were the top yielders in the same test harvested in 1959.

Agronomic data were collected on 45 sorghum varieties or hybrids in 13 performance trials at up to 6 locations for a 5-year period. Sart sorgo has consistently been the highest yielder but suffers considerable lodging at times. Tracy sorgo and DeKalb FS-1 (now FS-1a) have consistently demonstrated superior lodging resistance. All varieties and hybrids were lodged to some degree in the 1959 Pee Dee test (PD-59) due to Hubricane Gracie. Some of the new forage sorghum hybrids appear promising, especially with respect to yield of grain; however, more observations are needed, particularly in regard to their lodging resistance.

A mimeo covering the forage sorghum performance trials and one covering the sudan and millet trials to date in detail are being prepared and will be available on request.

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SPAIN

E. Sanchez-Monge (Madrid)

Trial at Alcala de Henares, full irrigation.

Variety	Yield qm./ha.*
Corn (Al. 427)	68.0
RS 650	63.5
Texas 660	62.6
" 620	62.3
" 601	53.2
RS 610	52.7
" 501	51.9
" 590	50.4
Texas 611	50.0
H - 11008	49.4

Trial at Jerez de Frontera, dry conditions.

Variety	Yield qm./ha.
Corn (DeKalb E 56A)	23.0
H - 11008	22.6
RS 610	22.0
RS 650	21.9
Texas 660	21.2
" 611	20.1
" 601	18.8
" 620	17.8
RS 590	15.4
RS 501	10.3

*Metric quintals (100 kg.) per hectare.

Trial at Aula Dei (Zaragoza), semi-dry conditions - one irrigation.

Variety	Yield qm/ha.
RS 610	24.7
RS 501	23.9
Texas 601	23.2
H - 11008	22.9
RS 650	21.6
RS 590	20.1
Texas 611	20.0
Texas 660	17.0
Texas 620	16.5

SUDAN

Sorghum in the Clay Plains of the Central Rainlands of the Sudan

W. M. Tahir and Hussain Idris (Wad el Nail)

Introduction

Sudan is one of the primary centers of origin of sorghum. From north to south there are varieties of sorghum to suit the variable environmental conditions. It is the staple food of the vast majority of some 11 million Sudanese and is used in many forms, mainly kisra (a thin pancake) and asida (a kind of porridge) prepared from dough. Abri (non-alcoholic) and marisa (alcoholic) are drinks prepared from the fermentation of sorghum. The straw of the crop is used as fodder, hut-building, fencing material and fuel.

There are innumerable sorghum types scattered through the country. Natural crossing confuses botanical classification, and Arabic nomenclature is even more confused. One type may have different names and one name may be used for several different types according to locality. Snowden (1) identified 36 varieties and 72 distinct forms in Sudan material. However, commonly grown sorghum types belong to only three main varietal groups:

(1) S. vulgare Pers. var. Caudatum stapf. This includes Snowden's varieties caudatum (e.g. Gadmel Hammam, Wad Akr), Feterita (e.g. Feteritas and Gassabi), gibbum (e.g. culum), natae (e.g. Bahana, Dinderawi), durum (e.g. Zirazira) and talodium (e.g. Wad el Fahl).

(2) S. vulgare Per. var. durra stapf. This includes highly palatable types like Mugad and Farhuda.

(3) S. vulgare var. subglabrescens, Schweinf et Aschers. Excellent sorghum types like Aklamoi of Gash and Tokar belong to this group.

Other varietal groups are restricted in distribution except wild sorghums collectively called Adar (Sorghum sp.) which are present throughout the country and freely cross with cultivated types.

Central rainlands

The Central Rainlands extend in a belt across the center of the Sudan, lying between 400 mm. and 750 mm. rainfall isohytes, and comprising an area of approximately 120,000 square miles (2). It includes two major agricultural soil types, viz., clay plains, and Kordofan and Darfur sands. At present large scale production of sorghum is confined to the heavy cracking alkaline clay plain soil of the east and centre which varies in color from grey brown to brown.

The clay plains are situated between approximately 12° - 14° N. latitude, and 33° - 36° longitude, and have mean annual variability in rainfall from 10 to 17% increasing from south to north. From a climatic and ecological standpoint, the clay plains are divisible into two more or less distinct agricultural regions. The northern region, including Gedaref and Dali mechanized crop production schemes, has a rainfall of 450-600 mm. and is suited to grow only sorghum, sesame and safflower. The southern region, including Tozi area, has a rainfall of 600-750 mm. and a great variety of crops like sorghum, cotton, maize, groundnuts, etc., can be successfully grown.

Mechanized crop production in rainlands

Up to 1945 sorghum was entirely a peasant crop grown mainly for local consumption and raised by traditional hand methods. A pilot mechanized scheme was started near Gedaref in northern part of the clay plains in 1945 with 20,000 acres (3). Sorghum production has since been completely revolutionized, and in the 1959 season there were about 1 3/4 million acres under large scale production in this region, and the area is still expanding very rapidly. Most of the farms are one tractor units with about 1,000 acres each. Sorghum is the only major crop grown on these farms at present. Sorghum follows sorghum resulting in low yield, not more than half a ton per feddan. An empirical rotation of four years sorghum followed by four years natural grass fallow is being followed. The crop is sown by seed-drills, and all other operations are done by hand except for a few schemes which use static threshers and fewer still which use combines.

Research work on sorghum

For the purpose of improving rainland agriculture and breeding varieties suitable for mechanization, a research station was opened at Tozi in 1952. Progress made in the field of sorghum is reported in this paper. Tozi is situated at N. lat. 12° 13' and E. long. 34°00' in the southern region of the clay plains. Mean annual rainfall is 700 mm. with a mean variability of about 12%. Effective rainfall is received from the end of June to the middle of October. Diurnal range of temperature during the second half of July to October is about 20° C. - 30° C., and dewpoint coincides with the minimum temperature of 20° C. Evaporation drops to 5 mm. and lower during this period. Diurnal range of temperature widens, dewpoint drops and evaporation rises greatly during November to June (4).

Sorghum Breeding

With the introduction of mechanized farming the need for combinable sorghum varieties arose for the first time in the Sudan in 1945. Indigenous varieties were not suitable for direct use in mechanization because these were either inherently too tall, goosenecked, profusely tillering and without any reasonable extrusion of head from flag leaf or they were a mixture of several types varying in height, maturity and other characters. A full range of American combinable

varieties was tested, but adaptability, yield and grain quality of these varieties were found inferior to the best local types. It therefore, became apparent that, although for evolving suitable agronomic practices for combinable sorghum some of the best suited American varieties could be profitably used, for large scale production varieties would have to be bred locally. With the opening of Tozi Research Station, a sorghum breeding program was started with both short-term and long-term objectives.

Short-term objectives

The first step was to isolate desirable basic types from local mixtures and outcrosses. Although these basic types would not be ideal for combine-harvesting, they should possess as many as possible of the following characters: (a) uniform combinable height, (b) lack or minimum of tillering, (c) uniform early to medium maturity, (d) good extrusion of head from the flag leaf, (e) resistance to local pests and diseases, (f) wider adaptability to variable climatic conditions of the rainlands, (g) high yield, and (h) high quality grain.

Commonly understood criteria for kisra type sorghum in the Sudan are (i) color and elasticity of dough, (ii) taste, and (iii) stability of color and elasticity of kisra itself. For marisa, the taste and quality of brew are the determining factors.

Selection work so far has been confined to Caudatum group of varieties. This group has a much wider genetic variability in the Sudan than varieties of Durra group which, due to their tallness, gooseneck, compact head and long maturity, are ill-suited to complete mechanization of sorghum in the rainlands. Durra types, however, have usually high quality kisra grain and can command up to 20% premium.

Pedigree line selection was started in 1952 in two varieties, Wad Akr and Feterita Maatuk, and every year new material has been added to this program.

Mugbash 1, Dinderawi and El Fadni have reached uniformity with regard to dwarfness, maturity and other characters, and their best lines are somewhat resistant to lodging. Abu Degais, Bahana, and Zirazira are in the final stages of selection. Zirazira has small grains of medium to fair quality.

Feterita Abu Direira, a good marisa type, and Gassabi, with excellent white flour for kisra, tiller very badly and are unsuitable for combine-harvesting. Both are resistant to lodging and mature early. Feterita Abu Direira also shows considerable resistance to central shoot fly (Atherigona sp.). Their extrusion can go up to one foot. They are useful material for hybridization.

L.R. 179, L.R. 45/1, 2, 3, G.H. 1, 2, 3, and Dinderawi are resistant to charcoal rot but, except L.R. 179, are susceptible to other stalk rots.

Varieties so far released are strains of T.U.B., Feterita Maatuk and Tozi Wad Akr. T.U.B. strains are comparable in combinability to American varieties, are drought resistant and adapted to the whole of the rainlands. They also show some degree of resistance to lodging. On the average of two years and three representative places of the rainlands, T.U.B. strains have given reasonably good yields and significantly outyielded both American varieties (Combine Kafir-60 and Bonita-Hegari) included in the tests. In higher rainfall areas of southern region, Tozi Wad Akr and Combine Kafir 60 are comparable in yield, but the latter is easily induced to tillering under wet field conditions.

Long term objectives

The strains being developed by the above procedure are far from perfect either in combinability or grain palatability. The next step was, therefore, to bring together by hybridization known characters from basic types. This was started in 1957. Quality type Gassabi and Zirazira have been crossed with combinable T.U.B. strains, Wad Akr and Bonita x Hegari. Maturity, combinability and drought resistance of Tozi Wad Akr are being improved by crossing with T.U.B. strains and Queensland Kalo. Further hybridization would be between quality types from Durra group and combinable types from Caudatum group.

American sorghum hybrids

American experimental station sorghum hybrids were obtained in 1958 and 1959 through courtesy of Dr. O. J. Webster, Nebraska Experimental Station, and compared with two Tozi selections, T.U.B. 7 and Wad Akr, and one American variety, Plainsman. All the hybrids were positively superior to Plainsman, giving an average increase of about 33% over TX 620. However, differences between T.U.B. 7 and the best American hybrids were small and statistically insignificant. Overall increase did not exceed 6%. Except RS 501, the hybrids were highly susceptible to lodging caused by stalk rots.

It therefore, appears that present American hybrids, though a great advance on American self-propagating varieties and have excellent combinable plant characters, would be of limited use in the rainlands. If, however, resistance of local varieties to lodging, diseases and pests, and grain quality is introduced into these hybrids, a new chapter will be opened in sorghum production of the rainlands.

Resistance to pests and diseases

A variety to be successful in the rainlands should possess some degree of resistance to the following pests and diseases of the sorghum crop.

(a) Diseases: Charcoal Rot (Sclerotium bataticola Taub), Colletotrichum Stalk Rot (Colletotrichum graminicolum), Sooty Stripe (Ramulispora sorghi (Ell. & Ev.) Olive & Lefebvre), Leaf Blight (Helminthosporium turcicum Pass.

(b) Pests: Weaver Bird (Quelea quelea aethiopica Sund), Grasshoppers (Aelopus sp.), Central Shoot Fly (Atherigona sp.), Sorghum Aphis (Aphis sorghi Theob), Stem Borer (Sesamia cretica Led).

Sorghum Agronomy

Owing to the recent rapid expansion in large scale sorghum production, revising and verifying the traditional production techniques were found necessary. A balanced healthy rotation, optimum time of planting, plant population, fertilizer applications, and best methods of weed control had to be determined.

Place in the rotation

A series of two year crop sequence experiments, i.e., growing several crops in the first year followed by one crop in the second year, showed that sorghum was the worst precursor for all crops including sorghum itself. The best preceding crops for sorghum were sesame, groundnuts, and sorghum green manure (sorghum

disced in 6 weeks after sowing). Sesame excelled groundnuts when the two seasons were moderately dry, sesame being shallower rooted and so left behind more moisture. Two empirical rotations were devised for Tozi in 1955 as follows:

A) Groundnuts - tall sorghum - sorghum green manure - cotton.

B) Maize - dwarf sorghum - sesame + N - cotton.

Several long term experiments were started in 1959 to test different combinations of the above crops.

Planting dates

Generally planting later than July and early August reduced yields significantly. Dwarf varieties were left less sensitive than tall varieties to delayed planting dates. This behaviour of the two types of varieties could be explained in terms of moisture requirements. Other crop characters like grain/total air dry matter ratios and flower stalk length were also adversely affected. The above finding verified the old belief of some farmers in the Sudan who tended to sow as late as August and September.

Planting populations

An important experiment carried out in 1954, showed that optimum yields could be obtained by sowing fairly early (experiment sown 22nd July) and adopting close spacing. This experiment and others proved that optimum populations for optimum yields should be 40,000 - 60,000 plants per feddan for medium - tall varieties, and 50,000 - 70,000 plants per feddan for dwarf varieties. These new ideas revolutionized sorghum husbandry and is considered now one of the major advances in sorghum improvement in the Sudan during recent years. Old practices used to raise populations as low as 10,000 plants per feddan.

Response to fertilizers

Nitrogen is the dominant factor needed by most crops in the central clay plains. Magnitude of response of sorghum to application of nitrogen depended greatly on the preceding crops. When sorghum followed groundnuts responses varied from 18-400 r.p.f.*for N which were generally uneconomic. When sorghum followed sorghum responses reached 700-1000 r.p.f. for N which under present prices of sorghum are just paying.

Phosphates are of minor importance. Small responses were obtained in presence of the heavy applications of nitrogen. No responses whatsoever were found to application of potash fertilizers.

Weed control

The practice carried out at present in most of the large mechanized sorghum production farms is to apply one to three presowing discings to kill weeds after their emergence. One to three more hand weedings were applied after the emergence of the crop, the first weeding being after three weeks from sowing.

*Rotls per feddan approximately equal to pounds per acre.

Work at Tozi showed that an inter-row cultivator, a steerage hoe type, could do the first weeding efficiently so that one more hand weeding would be enough. Sorghum was found a good smotherer of weeds when grown under high plant populations.

Recent work showed that 2,4-D could give good control of weeds on sorghum. Work is now continued on these lines.

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Acknowledgement

We are grateful to Dr. A. D. Hanna, Chief, Agricultural Research Division, for reading the manuscript and for his approval to publish this paper.

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TEXAS and USDA

Cold Soil Tests

Darrell T. Rosenow (College Station)

Seed of Martin, B3197, 7078, and Tx09 were placed in petri dishes containing sterile agar. Three replicates of 70 seed per sample were stored for three weeks at temperatures of 55, 50, 45 and 40 degrees F., and the number of seedlings with a plumule were counted. The following number were considered as germinating at 55 degrees: Martin - 120; B3197 - 105; 7078 - 114; and Tx09 - 112. At 50 degrees, 12 Martin seed germinated, two B3197, three 7078 and 70 Tx09. At 45 degrees, 1 Martin seed germinated, no B3197, no 7078 and 29 Tx09. At 40 degrees, 3 Martin seed germinated, no B3197 nor 7078 and 1 Tx09.

These experiments were repeated at 53, 50, 45 and 40 degrees F., and seed of Wheatland, Redlan, SA 3007, Hegari, and A & B 3048 were included. The temperatures in some of the germinators were slightly off, and the data were less reliable than from the first experiment. It was readily evident, however, that this sample of Tx09 would germinate under colder conditions than most of the others and that this sample of 7078 germinated very poorly at low temperatures. Wheatland also showed promise of germinating in cold soils. This research will be continued on a larger scale in 1960 and most of the old sorghum varieties will be checked.

Rating of Plants for Hydrocyanic Content

Lee C. Coffey and E. C. Holt (College Station)

The sodium picrate test was used for rating sudan varieties and hybrids for prussic acid potential. Approximately 40 new varieties and hybrids were tested and compared to varieties of known prussic acid content. It is our opinion that this test is satisfactory for rating nursery material for hydrocyanic acid potential as long as a few varieties of known hydrocyanic content are included. Information on how to run the test probably could be obtained from a local veterinary department or would be furnished on request.

Head Smut Study

Lee C. Coffey

Approximately 4,000 rows of segregating populations, varieties, hybrids, and selections were planted in a field in which 7078 had averaged approximately 35% head smut the previous year. Four varieties were planted at 4 different dates, but there was no significant difference in the percent of smutted plants from the different dates of planting. Most state and federal experiment stations had material in this study. The Feteritas and Hegaris were resistant while some of the milos were quite resistant and others very susceptible. The Kafir types seem intermediate in susceptibility. Combine 7078, KS 1, and Leoti were some of the more susceptible varieties. The percentage of susceptible plants of each variety will be published later.

Control of Field Mold and Bird Depredation with Field Application of Arasan 42-S

Robert B. Metzer (College Station)

Field mold (Alternaria) was reduced on Combine kafir seed grown near Prairie View, Texas, in 1958 with field applications of Arasan 42-S at rates of one gallon per acre applied during the milk stage of growth. The one gallon per acre rate was less effective when heads were treated during the hard dough stage of growth. The lower rates of application ($\frac{1}{2}$ and $\frac{1}{4}$ gallon per acre) did not visibly reduce mold development at either stage of growth.

In another test near College Station, Texas, in 1959, rates of 3/4 and $1\frac{1}{4}$ gallons of Arasan 42-S per acre applied at either the milk or hard dough stage of growth were effective in reducing field mold development on Combine kafir. The reduction in mold development resulted in brighter, natural colored seed at both test areas. Effectiveness of Arasan 42-S for inhibiting field mold development will vary according to weather conditions during the maturation period, and rates as high as $1\frac{1}{4}$ gallons per acre may be necessary in years of above normal humidity and rainfall.

Arasan 42-S contains 42% Thiram, but concentrations of 1% and 5% actual Thiram were very effective in repelling birds such as English sparrows from a fall sorghum nursery at College Station, Texas, in 1959. Individual head treatment was necessary

in this test due to differences in maturity; therefore, the gallonage per acre was not established. However, each head was thoroughly covered by the Arasan 42-S solution to insure adequate treatment.

The Effect of Seed Treatment on Laboratory Germination and Field Emergence at Chillicothe, Texas

J. R. Quinby (Chillicothe)

The effects of seed treatments on field emergence and seed storage of sorghum have been studied during four years at College Station and Chillicothe, Texas, using 24 treatments and seven varieties. The data will be published elsewhere. In December of 1957 and two years after treatment, the laboratory germination of the 168 lots of seed was determined. The field emergence of these lots was then obtained from a planting in May, 1958. The results with seven treatments on one hybrid and two varieties is presented. Seed of the Honey variety was of poor germination when treated.

The seed treatments had relatively little effect on laboratory germination. The organic compounds were more effective in raising field emergence than the mercuricals. However, the emergence of the persistent glumed variety, Honey, was increased substantially by treatment with the mercuricals.

Only about 60 percent of the live seed with the most beneficial treatments emerged in the field. Seed treated with the least effective chemicals emerged as well as those without treatment but only about half as well as from the most effective treatments.

The Effect of Seed Treatment on Laboratory Germination and Field Emergence at Chillicothe, Texas.

Treatment	Martin			Texas 620			Honey			Av. % emerg. of live seed
	Lab.* germ.	Field** emerg.	% emerg.	Lab. germ.	Field emerg.	% emerg.	Lab. germ.	Field emerg.	% emerg.	
Captan 50W	91	58	64	78	53	68	23	11	48	60
Delsan A-D	88	47	53	80	45	56	27	18	67	59
Spergon	88	42	48	77	44	57	27	16	59	55
Cerasan SF X	93	50	54	85	50	59	29	12	41	51
Panogen 15	90	24	27	82	24	29	23	12	52	36
Ceresan 75	86	24	28	84	11	13	24	12	50	30
None	90	22	24	86	18	21	25	11	44	30
Average	89	38	43	82	35	43	25	13	52	46

*Laboratory germination determined in December, 1957.
**Field emergence determined from a planting on May 20, 1958.

The Inheritance of Duration of Growth in the Hegari Group of Sorghum

J. R. Quinby

The Hegari group of sorghum is considered to consist of Hegari, Early Hegari, Combine Hegari, Hi-Hegari, Bonita, and Combine Bonita. From this group, the maturity genes of Hegari, Early Hegari and Bonita have been studied. Hegari is genetically ABc, Early Hegari Abc and Bonita aBC. It is thought that A is the Ma_1 of the milo group, B is Ma_2 and C is Ma_3. This identification of the A, B, and C genes will be verified during the coming growing season.

Measuring the Rate and Extent of Root Growth of Sorghum with Aid of Radio-active Tracers

J. G. King, N. W. Kramer, and Jerry McClure (Lubbock)

A study was initiated during 1959 to determine the rate and extent of root growth of Texas 620 and SA 385 in the hopes that some measuring device could be established that would help in drouth tolerance studies.

The technique used was similar to that reported in the North Carolina Agricultural Technical Bulletin No. 101, 1953. Seed of the Texas 620 and Combine Kafir-60 were planted in replicated plots eight rows wide with only the second, third, sixth, and seventh rows being used. In utilizing these four rows, the hills were located alternately at a distance of seven and one-half feet between plots on adjoining rows in order to insure that no plants would withdraw the P_{32} from an adjoining hill or transfer the tracer material by roots.

A solution of ten millicuries of P_{32} per millileter was used, with ten milliliters of solution injected with each application. Holes were placed at a 30 degree angle from the vertical to minimize channeling of the roots. Four applications were made to each plant, six inches apart, thus forming a one-fourth arc for the roots to penetrate. Placements were made at depths of 10, 20, 30, and 40 inches at distances of 0, 10, 20, 30 and 40 inches from the plants.

A hypodermic syringe was used to measure ten cc solution into each individual application. One-fourth inch glass tubing was inserted into the channels left by the soil probe and solution injected through the tube.

A portable geiger counter was used in taking daily readings of the radioactivity present in the plants. Two readings were taken each day, one in the morning and the other in the evening.

Results of this preliminary study are presented in the following table.

Treatment		Week roots reached treatment	
Depth in.	Width in.	Texas 620	SA 385
10	0	2	2
20	0	3	3
30	0	4	4
40	0	4	7
10	10	2	4
20	10	5	5
30	10	6	6
40	10	8	-*
10	20	5	6
20	20	7	6
30	20	7	7
40	20	9	11
10	30	6	6
20	30	6	7
30	30	7	8
40	30	10	11
10	40	8	6
20	40	9	8
30	40	10	10
40	40	-**	-**

*Missed treatment
**Radioactive material decayed beyond sensitivity pickup

Charcoal Rot Nursery

N. W. Kramer, J. G. King and T. E. Haddox (Lubbock)

A charcoal rot nursery was established at Lubbock in 1959 to search for possible sources of genetic resistance to Macrophomina phaseoli, the causal agent of the disease. Plants were artificially inoculated with the organism, and the nursery was grown under controlled moisture conditions known to be favorable for the development of the disease.

Materials planted for the study consisted of 165 progenies representing a cross-section of the advanced breeding material at Lubbock, 50 strains from Clovis, 22 lines from Lincoln, and 712 I_2 progenies of 3197B, 7078 and Tx07. Moisture was maintained at a high level early in the season, and the plants were allowed to go into severe moisture stress after the boot stage. About one week after blooming five plants in each progeny were inoculated by the toothpick method in an internode about two inches above the soil. The inoculum and assistance with techniques were supplied by Dr. D. H. Hsi of the New Mexico Agricultural Experiment Station. Lines were evaluated in November and December by splitting the inoculated plants and counting the number of internodes of upward spread of the organism from the point of infection.

Differences in susceptibility to Macrophomina phaseoli, as measured by these methods, were apparent in all the groups of materials. A few lines showed reactions to the infection that suggest the occurrence of a high degree of resistance. In many lines there was considerable variation between plants in the reaction to the infection.

The results from 1959 are considered preliminary at this time. Selections from the more resistant lines will be checked in 1960 to again measure their reaction to the organism.

Inheritance of Partial Fertility

N. W. Kramer, J. G. King, and T. E. Haddox

Observations in certain materials at Lubbock in 1959 showed an unexpected increase in partial fertility with additional backcrossing for the development of male-sterile lines. In the materials observed, $A_1 \times B_2$ was completely sterile, $(A_1 \times B_2) \times B_2$ had some partial fertility, and $(A_1 \times B_2) \times B_2 \times B_2$ had even more partial fertility.

Two possible genetic explanations are proposed for this increase expression of partial fertility with backcrossing:

(1) Dominant genes functioning as suppressors of partial fertility occur in A_1 and B_1, and B_2 carries the recessive alleles of these genes.

(2) An epistatic system conditioning complete sterility occurs in A_1 and B_1, but B_2 lacks some of the alleles necessary for this system to produce complete sterility.

Research on Irrigated Grain Sorghum Production

W. H. Slettin (Bushland)

High Plains farmers of Texas have an unlimited acreage of land suitable for irrigation, but unfortunately water from deep wells is either expensive or in short supply. Many farmers apply irrigation water during fallow season (preplant irrigate) to as much acreage as they can. After planting they depend on the amount and distribution of seasonal rainfall for maintaining a profitable farm.

Practices which bring about high water-use efficiency are desirable and necessary in any irrigation enterprise. To conserve the water supply of the High Plains by determination of most profitable practices is the basis for extensive research.

Extensive research has been done at the Southwestern Great Plains Field Station at Bushland and The Texas Agricultural Experiment Station at Lubbock on various grain sorghum production aspects, such as weed control, fertilizer requirement, water use, variety selection, etc. Some of these studies have been reported in previous newsletters. Determining how combinations of desirable practices might further increase water-use efficiency has been the objective of recent experiments at Bushland. To date only certain aspects of these irrigation sorghum investigations have been reported.

Three separate sorghum production experiments were initiated in 1956 by M. E. Jensen, K. B. Porter, and W. H. Sletten.

One of these experiments, entitled "The effect of row spacing, fertilizer, and planting rates on yield and water use of irrigated grain sorghum" has been terminated and publications prepared.*

A second experiment, "Irrigation water management, consumptive use, and fertilizer studies on irrigated grain sorghums," has been reported in part.** Reducing the planting rate from 12-15 pounds per acre to 6 pounds per acre, does not reduce the potential for a high grain yield where nitrogen is adequate and rainfall and/or irrigation water is ample.

The third experiment, "Management of irrigated soils for improving water intake rates and plant-soil relationships," is now in its fourth crop season. Various cropping and tillage practice combinations are being evaluated as to their effect on intake rates and grain sorghum yield. Cropping practices are: continuous grain sorghum; continuous grain sorghum with interplanted cowpeas; and two years of alfalfa followed by grain sorghum. These three cropping practices are used with three tillage practices, which are: stubble mulch, surface (3-inch) tilled using sweeps and disk harrow; moldboard plowed 7 inches deep; and, rough or deep chiseling (subsoiled) 15 inches deep. Adequate nitrogen and water are supplied to these treatments. Reports will be prepared when the effects of the treatments and the duration of these effects are determined.

Pre-emergence Herbicides for Irrigated Sorghum

A. F. Wiese and H. E. Rea (Bushland)

During 1956, 1957 and 1958 several chemicals were evaluated for pre-emergence weed control in irrigated sorghum. Either Redbine-66 or RS 610 hybrid sorghum was planted in level borders and received approximately 25 inches of rainfall and flood irrigation water during the growing season. The crops were pre-irrigated and received 2 or 3 additional irrigations depending on rainfall. Weeds present in the test sites were pigweed (Amaranthus retroflexus), puncture vine (Tribulus terrestris) and crab grass (Digitaria sanguinalis). Chemicals tested were monuron, diuron, neburon, CIPC, CDAA, sodium salt of 4-(2,4-DB), sodium salt of N-1-napthyl phthalamic acid, tris-(2,4-dichlorophenoxyethyl) phosphite, TBA, 2,3,6-trichlorophenylacetic acid, 2-chloro-4, 6-bis (isopropylamino)-s-triazine, 2-chloro-4-diethylamino-6-isopropylamino-s-triazine and 2-chloro-4-methylamino-6-isopropylamino-s-triazine and simazin. Of all chemicals studied 2-chloro-4, 6-bis (isopropylamino)-s-triazine appears to be the most promising for pre-emergence weed control in sorghum.

Entomological Studies

Norris E. Daniels (Bushland)

Insecticidal control of soil insects

Heptachlor, Endrin, Dieldrin, Aldrin and Diazion were applied during the spring of 1959 to 8' x 50' plots replicated three times. The insecticide granules were

*See Porter et al. (2 publications).
**See Mathers et al., and Jensen et al. (3 publications).

applied with a belt drill, as soil treatments, at the rate of 1.6 pounds actual per acre. Two sets of plots were treated; one set on a sorghum-fallow-wheat rotation and the other set on continuous sorghum. Plantings of RS 610 hybrid sorghum were made with a surface two-row (20-inch rows) planter at the rate of 2.3 pounds per acre. There were very few soil insects found in the rotation plots. Soil insects varied in the continuous plots averaging about 6 per square foot. Sixty-five percent of the larvae were Cababidae, which were probably not harmful, and 35 percent Elateridae, a wireworm, Aeolus sp. Good larval control was realized 5 days after chemical treatment. Sorghum yields were apparently not lowered by either the chemicals or insects. Seed yields averaged 31 bushels per acre on the rotation plots and 6 bushels per acre on the continuous plots.

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UGANDA

Sorghum Work in East Africa

H. Doggett (Serere, Soroti)

The approximate African populations of the three main territories are: Kenya, 6 million; Tanganyika, 8.5 million; Uganda, 5.5 million. Reliable acreage figures are difficult to obtain, but the acreage under grain sorghum is around 2 million, made up of Kenya, 0.4; Tanganyika, 1.0; Uganda 0.6. There is a large group of banana-eating tribes in Uganda and some in Tanganyika; otherwise the main staples are maize, sorghum, Eleusine millet and Pennisetum millet. Sorghum was probably the most important cereal originally, but maize now fills that position. Maize will always occupy the more reliable rainfall zones, but there are substantial areas of irregular rainfall well suited to sorghum.

The sorghum grain is used largely for human food, although a substantial amount is made into beer. There is no stock feeding as yet, nor is it likely to come in the near future. Maize has become popular because it has a white, palatable grain which is not troubled by birds, and it is easy to handle. There is, therefore, a tendency for maize to be grown in marginal areas, where it is unreliable. Breeding work to find maize types suitable for harder conditions is being undertaken and will yield valuable results, but I have no doubt that there is a limit to this extension of maize, and with a rising population sorghum will become increasingly important.

The agriculture is still very simple, individuals cultivating rather small plots by hand or with the aid of ox plows, with nearly all the weeding and harvesting done by hand. Individuals grow and store their own food, selling or brewing up any surplus. Their money requirements are met by growing so called "cash crops" such as coffee and cotton, or by the sale of cattle. Cattle are cheap, fertilizers relatively expensive and scarcely used. The growers are not accustomed to purchasing seed, and there are no seed suppliers. The grain crops are usually grown as a mixture of types; a uniform plot sown to one variety is rare.

Against this background, the plant breeding objectives must be to develop sorghums which will have an acceptable grain type for human food relative to maize, and which can give consistent yields under rather difficult growing conditions and low farming standards. The plant breeder must also bear in mind that seed issued

will be kept by the grower, and fresh purchases will not be made annually. Indeed, a good deal of the seed renewal will take place through barter and exchange among the growers. Of course, the future developments of grain as stockfeed and the possibility of farmers purchasing seed annually must be remembered, but these lie some way ahead.

I did some preliminary sorghum breeding work with the Tanganyika Government, and now a Sorghum Research Unit has been set up as part of the East African Agricultural and Forestry Research Organization. Dr. David Jowett joined me in November, 1959, and the pair of us are working for the whole of East Africa.

Preliminary work had shown that the corneous grain types which are white throughout are the most acceptable food types, which also keep better without excessive weevil damage when stored as threshed grain. They are also the types most readily taken by birds, and cannot be grown in most areas for this reason.

Birds

We are approaching this problem in two ways. Firstly, by "bird resistance", for want of a better term. Large areas of brown grained sorghum have been grown for years. If white palatable types are planted, the birds strip them. As an illustration, 5,000 acres of sorghum were grown by the Overseas Food Corporation at Kongwa, Tanganyika, in 1952, 3,000 of Dwarf Kafir 44-14 and 2,000 of Dobbs (brown grain). The birds stripped the Kafir and left the Dobbs untouched, though both have the same length of maturity here. The presumption is that there is normally enough grass seed for food, and the palatable sorghum varieties are taken because of their flavor, and not because the birds are hungry. It may, therefore, be possible to develop types which the birds will find too much bother to take, and so will revert to the wild grass seeds. To this end, we are combining together the palatable corneous grain type with large glumes, pendant heads, and long awns. All these characters have some small value individually, so that combination is worth trying. We have some good glume cover from Feki Mustahe crosses, with fairly long awns, but there is still a long way to go.

The second approach, and in the long run the more likely to be successful, is the development of brown types which will give a good flour after decorticating. The practical application of this will be dependent on the installation of simple and robust decorticating machines in the villages, to which people would bring their grain to be pearled for a small charge. Jowett is now studying a wide range of grains.

The great advantages of hybrid sorghum cannot be utilized at present. I am informed that there are no prospects of the growers purchasing relatively expensive hybrid seed each year. In order to try to reap some of the benefits of hybrid vigour, a tetraploid program has been started. Tetraploidy may help incidentally in giving tougher glumes, longer awns and larger grains, in addition to a slower run-down of hybrid vigour.

Tetraploids

A cross between two rather closely related autotetraploids was made in 1955, and has been selected for good seed set since. Progress is shown in the following table.

	Parent A	Parent B	F_1	F_2	F_3	F_4	F_5	F_6
% seed set	32.4	18.4	65.1	66.5	56.3	74.8	70.5	78.3
Angular transformation	34.8	25.0	53.7	54.8	48.3	60.1	57.3	62.5
S.E.	8.2	7.1	9.9	8.1	9.0	6.3	9.1	4.3
Set as % of diploid, all data	40	23	80	82	70	79	76	82
Best family				82	87	84	80	83

It appears that the real increase in seed set occurred on crossing. There appears to have been no progress in increasing the seed set above the best F_2 selections, but the variance within the progeny rows has been reduced. This result from crossing two closely related lines is sufficiently promising to justify further studies. Over 100 varieties have been treated with colchicine this year, from different geographical areas and of different races. These will be intercrossed at the tetraploid level in various combinations. We hope to get some really fertile tetraploids out of this, and incidentally we may pick up some useful information on sorghum relationships, guessing that seed set in tetraploid hybrids will vary with the degree of affinity of the parents. The crosses will be repeated at the diploid level for comparison, and also to locate the best combiners for future breeding work.

Other studies will be recorded in the next letter. Finally, I should like to thank again all the workers who made my visit last year to the United States and Mexico so valuable and pleasant. It was extremely encouraging to see what has been done with the sorghum crop. I came back convinced that it has a big future in East Africa.

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U. S. DEPARTMENT OF AGRICULTURE

A Preliminary Report on an Environmental Study of Sorgo in Mississippi and Georgia*

O. H. Coleman (Meridian, Miss.), I. E. Stokes (Beltsville, Md.), and E. S. Lyons (Cairo, Ga.)

Introduction

The practice of selecting from early generations of any crop at only one location may limit the range of adaptation of the resulting improved varieties. For example, sorgo (Sorghum vulgare Pers.) varieties developed at Meridian, Mississippi, might not be well adapted to the environmental conditions of south Georgia, or Maryland. To determine whether sorgo selections made at Meridian are equally adapted to areas similar to those in south Georgia, a group of early-generation hybrids were grown at the two locations during several years to determine the importance of selection under both environmental conditions.

*Cooperative investigations between the Crops Research Division, ARS, USDA, and the Mississippi Agricultural Experiment Station.

Experimental Procedures

In 1953, twenty-one promising early-generation sorgo lines were planted at Meridian, Mississippi, and Cairo, Georgia. The best plants at each location were bagged and selected for study in 1954. In 1954 and 1955, the best plants were again selected for study. During the period of reselection many of the original lines were discarded because of undesirable characteristics. In 1956, seed of the 4 best pairs of selections were available. These paired lines, which had been selected for 3 years at Meridian and at Cairo, respectively, were planted in similar tests at Meridian, Cairo, and Beltsville, Maryland.

These tests were laid out in split-plot designs of 5 replications. Selections were the main plots and sources of seed the subplots in each test. Each subplot was a single row. At Meridian and Cairo, subplots were 1/1000 acre, whereas at Beltsville, they were 1/600 acre.

Various data were collected at the 3 locations, but only yields of stripped stalks, percent of juice extracted, and Brix (percent soluble solids, mostly sugars) of the extracted juice are reported in this paper.

Results

The variance analysis of sorgo environmental tests at Meridian, Mississippi, and Cairo, Georgia, is shown in Table 1. It is apparent that the selections differed in yield of stalks per acre, but that most of the interactions were not significant. A slight interaction between the source of seed and the selections was indicated. This indicates that selection for yield was not consistent at the two locations.

The highly significant extraction variance for locations was due to the fact that the mill at Cairo did not extract as high a percentage of the juice from the stalks as the one at Meridian. The significant mean square for sources was influenced by selection pressure for juiciness in the experiments at Meridian whereas no selection was made for this character at Cairo. This selection pressure was obtained by splitting the superior stalks and selecting on the basis of juiciness of the stalk.

Highly significant variances are indicated for locations, selections, and locations x selections for the Brix of the juice. Thus, the selections differed among themselves in juice quality and as a group had better quality at one location than at the other. The highly significant variance for the interaction source x selections indicates that quality of the selections was not consistent at the 2 locations. This interaction cannot be explained on the basis of different methods of technique, because Brix readings were not available for evaluation of the plants as they were being selected in the field. The interactions source x location and source x selection x location were not significant. The non-significant interaction source x locations indicates that it is not necessary to select at both Cairo and Meridian to develop varieties adapted to both areas.

The data are briefly summarized in Table 2. It is apparent that the yield of stalks per acre and the Brix were not affected by the place of selection. Detailed varietal data not shown in Table 2 indicate that the best variety at Meridian was also usually best at Cairo and Beltsville.

The percent juice extracted was influenced by the place of selection but as mentioned previously, this was due to the absence of selection pressure towards juiciness at Cairo.

Conclusions

Selection of sorgo at Meridian, Mississippi, for sirup and sugar production can be expected to develop superior varieties that will, for the most part, also be superior at Cairo, Georgia, and Beltsville, Maryland.

Selection pressure towards juiciness tends to develop juicier stalks even in fairly juicy populations.

Table 1. Analysis of variance of the sorgo environmental tests at Meridian, Mississippi; and Cairo, Georgia; during 1956.

Factor	D.f.	Mean squares		
		Yield of stalks per acre	Percent juice extracted	Brix of juice
Soil	8	20.69	8.20	1.49
Locations	1	24.87 NS	1316.25 **	55.61 **
Selections	3	101.84 **	25.26 NS	13.00 **
Loc. x Sel.	3	19.97 NS	26.98 NS	5.14 **
Error (a)	24	9.22	11.87	0.68
Plots	39			
Sources	1	9.39 NS	66.07**	0.09 NS
Soil x Sel.	3	29.31 *	4.91 NS	6.33 **
Soil x Loc.	1	7.66 NS	0	0.01 NS
Soil x Sel. x Loc.	3	4.70 NS	14.20 NS	1.38 NS
Error (b)	32	7.34	5.77	0.70
Total	79			

* = Significant at the 5% level
** = Significant at the 1% level
NS = Not significant

Table 2. Sorgo environmental tests at Meridian, Mississippi; Cairo, Georgia; and Beltsville, Maryland; during 1956.*

Location	Yield of stalks per acre			Juice extracted**			Brix of juice		
	M_3	C_3	Mean	M_3	C_3	Mean	M_3	C_3	Mean
	tons			percent			degrees		
Meridian	15.8	17.2	16.5	53.0	51.2	52.1	18.7	18.7	18.7
Cairo	15.4	15.4	15.4	44.9	43.1	43.1	17.1	17.0	17.0
Beltsville	19.4	16.4	17.9	--	--	--	12.4	13.3	12.8
Mean	16.9	16.3	16.6	49.0	47.1	48.0	16.1	16.3	16.2

*M_3, selected 3 generations at Meridian, Miss.; C_3, selected 3 generations at Cairo, Ga.

**Extraction data were not collected at Beltsville, Maryland.

Sorghum, A Possible Pulp Source?

I. A. Wolff (Peoria, Ill.)

Recent French publications by Escourrou* suggest that sorghum can be a most suitable papermaking raw material. Such usage in general demands a plant with maximum fibrous cellulose and "woodiness," minimum solubility or sugar content. Breeding objectives might be diametrically opposite for developing a good pulp material as compared with obtaining a most desirable forage.

The Northern Regional Research Laboratory at Peoria, Illinois, in cooperation with the New Crops Research Branch, Crops Research Division, Beltsville, Maryland, both agencies of the Agricultural Research Service, U. S. Department of Agriculture, is testing selected strains of sorghum for possible pulping value.

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*See in list of publications.

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III. MAILING LIST

Anderson, R. A., Engineering and Development Lab., Northern Util. Res. and Devel. Div., 1815 N. University, Peoria, Ill.
Andrews, D. J., Regional Research Station, Ministry of Agriculture, Samaru, Zaria, N. Nigeria
Anibal, Arriaga M., Instituto Agropecuario Nacional, La Aurora, Guatemala
Arnon, I., Agricultural Research Station, P. O. Box 6, Beit Dagan, Israel
Atkins, R. E., Department of Agronomy, Iowa State University, Ames, Iowa
Atkinson, Harold, Corn States Hybrid Service, 803 Keo Way, Des Moines 14, Iowa
Baker, Raymond, Pioneer Hi-Bred Corn Co., Johnston, Iowa
Banks, D. J., Dept. of Agronomy, Auburn University, Auburn, Ala.
Baylor, J. E., Dept. of Agronomy, Pennsylvania State University, University Park, Penn.
Beatty, K., Southwestern Irrigation Field Station, U. S. Dept. of Agriculture, P. O. Box 1339, Brawley, Calif.
Bhatti, A. G., Fodder Research Station, Sargodha, West Pakistan
Birnie, Georgette, Botany Division, Indian Agric. Res. Institute, New Delhi 12, India
Bogdan, A. V., Grassland Res. Sta., Dept. of Agric., P. O. Box 450, Kitale, Kenya, East Africa
Borgaonkar, D. S., Dept. of Botany and Plant Pathology, Okla. State Univ., Stillwater, Okla.
Bovie, R. W., Dept. of Agronomy, Agric. Exp. Sta., Lincoln 3, Nebr.
Boyd, F. T., Old Plantation Field Laboratory, 5305 Southwest 12th St., Ft. Lauderdale, Fla.
Brown, A. R., Dept. of Agronomy, Univ. of Georgia, Athens, Georgia
Browing, D. R., Southern Illinois State University, Carbondale, Ill.
Burton, G. W., Coastal Plain Exp. Sta., Tifton, Ga.
Byerly, W., Production Dept., Pioneer Hi-Bred Corn Co., Johnston, Iowa
Camp, L. M., Pfister Assoc. Growers, Aurora, Ill.
Campbell, M. A., Garst & Thomas Hybrid Corn Co., Coon Rapids, Iowa
Carter, J. F., Dept. of Agronomy, North Dakota State College, Fargo, N. D.
Casady, A. J., Dept. of Agronomy, Kansas State University, Manhattan, Kans.
Cavanah, L. E., Dept. of Field Crops, University of Missouri, Columbia, Mo.
Chada, H. L., Dept. of Entomology, Oklahoma State University, Stillwater, Okla.
Chessmore, Roy A., Noble Foundation, Box 870, Ardmore, Okla.
Claasen, C. E., Pacific Oilseeds, Inc., 97 West Main, Woodland, Calif.
Cobb, W. C., Office of Publications, Rockefeller Foundation, 49 W 49th St., New York 20, N. Y.
Coelho de A. Lima, Mario, Secao Experimental, Av. San Martin (Bougi), Recife, Brazil
Coffey, L. C., Dept. of Agronomy, Texas A & M College, College Station, Tex.
Coleman, O. H., USDA Field Station, Route 6, Meridian, Miss.
Collier, J. W., Agr. Exp. Sta., Temple, Tex.
Cook, D. S., Cargill, Inc., 200 Grain Exchange, Minneapolis 15, Minn.
Cook, E. D., Agr. Exp. Sta., Temple, Tex.
Cormu, A., Service de la Recherche Agronomique, Ministere de l'Agriculture, 99 Avenue de Temara, Rabat, Morocco
Craigmiles, J. P., Dept. of Agronomy, Agr. Exp. Sta., Experiment, Ga.
Crowley, A. J., Dept. of Field Crops, N. Carolina State College, Raleigh, N. C.
Curtis, D. L., Regional Research Station, Ministry of Agriculture, Samaru, Zaria, N. Nigeria
Cypert, E., Plains Substation, Clovis, New Mexico

Daniels, N. E., Southwestern Great Plains Field Station, Bushland, Tex.
Danlogh, H., Office of the Director, College of Agriculture, Potchefstroom, South Africa
Davies, Frank, Dept. of Agronomy, Okla. State Univ., Stillwater, Okla.
Denman, Charles, Dept. of Agronomy, Okla. State Univ., Stillwater, Okla.
de Wet, J. M. J., Dept. of Botany and Plant Pathology, Okla. State Univ., Stillwater, Okla.
Dhawan, C. L., Botany Division, Indian Agricultural Research Institute, New Delhi 12, India
Dobson, J. W., Agricultural Experiment Station, Blairsville, Ga.
Doggett, Hugh, East African Agriculture and Forestry Research Organization, Sere, P. O. Soroti, Uganda, E. Africa
Editorial Clerk, Cereal Crops Research Branch, Plant Industry Station, Beltsville, Maryland
Everly, R. T., Dept. of Entomology, Purdue Univ., Lafayette, Ind.
Feldman, Sheldon, Mishkevot 61, Beersheba, Israel
Finley, Don, Pioneer Hi-Bred Corn Co., P. O. Box 481, York, Nebr.
Fowler, Wayne L., Kansas Crop Improvement Assoc., Kansas State Univ., Manhattan, Kans.
Franzke, C. J., Dept. of Agronomy, South Dakota State College, Brookings, S. D.
Frazier, Floyd W., Agric. Exp. Sta., Akron, Colo.
Frey, K. J., Dept. of Agronomy, Iowa State Univ., Ames, Iowa
Fry, E. S., Amak, Inc., P. O. Box 3087, San Antonio, Tex.
Garner, George B., Dept. of Agricultural Chemistry, Univ. of Missouri, Columbia, Mo.
Gilmore, Earl C., Texas Agr. Exp. Sta., Denton, Tex.
Grassl, Carl O., U. S. Sugarcane Field Station, Box 421, Canal Point, Fla.
Grennell, M. G., Northrup, King & Co., P. O. Box 6036, Capitol Station, Phoenix, Ariz.
Grissom, Dale, Northrup, King & Co., Route 2, Box 433, Woodland, Calif.
Gross, C. F., Dept. of Agronomy, Penn. State Univ., University Park, Penn.
Hackerott, H. L., Ft. Hays Exp. Sta., Hays, Kans.
Haddox, T. E., Agricultural Exp. Sta., Route 1, Lubbock, Tex.
Hadley, H. H., Dept. of Agronomy, Univ. of Illinois, Urbana, Ill.
Harris, H. B., Dept. of Agronomy, Agr. Exp. Sta., Experiment, Ga.
Harris, H., Agr. Exp. Sta., Colby, Kans.
Hartley, William, Division of Plant Industry, Commonwealth Scientific and Industrial Research Organization, P. O. Box 109, City, Canberra, Australia
Hatchett, J. H., Dept. of Entomology, Okla. State Univ., Stillwater, Okla.
Hauswirth, E. A., Facultad de Agronomia, Chacabuco 243, Tucuman, Argentina
Heath, M. E., Dept. of Agronomy, Purdue University, Lafayette, Ind.
Henderson, C. F., Dept. of Entomology, Okla. State Univ., Stillwater, Okla.
Hillier, J. C., Dept. of Animal Husbandry, Okla. State Univ., Stillwater, Okla.
Hinze, Greg, Dept. of Agronomy, Colorado State University, Ft. Collins, Colo.
Hirata, Y., Research Dept., Corn Products Co., P. O. Box 345, Argo, Ill.
Hittle, C. N., Dept. of Agronomy, Univ. of Illinois, Urbana, Ill.
Kinzer, H. G., Dept. of Entomology, Okla. State University, Stillwater, Okla.
Hogg, P. G., Delta Branch Exp. Sta., Stoneville, Miss.
Holland, R. F., DeKalb Agric. Assoc., Route 2, Lubbock, Tex.
Hood, E. L., Dept. of Agronomy, Purdue University, Lafayette, Ind.
Holt, E. C., Dept. of Agronomy, Texas A & M College, College Station, Tex.
Hsi, C. H., Plains Substation, Clovis, New Mexico
Hunter, R. H., Southern Great Plains Field Station, Woodward, Okla.
Idris, H., Tozi Research Station, Wad El Nail, Sudan
Jensen, M. E., Southwestern Great Plains Field Station, Bushland, Texas
Johnson, Elmer C., Rockefeller Foundation, Calle Londres, 40, Mexico 6, D.F., Mexico

Kalton, R. R., Rudy-Patrick Seed Co., 114 8th St., Ames, Iowa
Karper, R. E., Agr. Exp. Sta., Route 1, Lubbock, Tex.
Khan, Tahir Ali, Dept. of Agronomy, Oklahoma State University, Stillwater, Okla.
Kidd, Harold, Pioneer Hi-Bred Corn Co., P. O. Box 788, Plainview, Tex.
King, Cooper, Dept. of Agronomy, Auburn University, Auburn, Ala.
King, J. G., Agr. Exp. Sta., Route 1, Lubbock, Tex.
Koehler, C. L., W. O. McCurdy & Sons, Fremont, Iowa
Kramer, N. W., Agr. Exp. Sta., Route 1, Lubbock, Tex.
Kroloff, Kirk, Advance Seed & Grain Co., P. O. Box 6157, Phoenix, Ariz.
Lahr, Keith, Agr. Exp. Sta., Chillicothe, Tex.
Langford, W. R., Regional Plant Introduction Station, Experiment, Ga.
Leonard, W. H., Dept. of Agronomy, Colo. State Univ., Ft. Collins, Colo.
Lewis, W. M., Dept. of Field Crops, North Carolina State College, Raleigh, N. C.
Lindsey, J. W., Lindsey Seed Co., P. O. Box 3133, Lubbock, Tex.
Livers, R. W., Plains Substation, Clovis, New Mexico
Loden, H. D., Paymaster Farm, Box 2, Aiken, Tex.
MacMasters, M. M., Cereal Crops Lab., Northern Util. Res. and Devel. Div., 1815 N. University, Peoria, Ill.
McBride, Charles, Dept. of Field Crops, Univ. of Missouri, Columbia, Mo.
McClain, E. F., Dept. of Agronomy, Clemson College, Clemson, S.C.
McClure, J., Agr. Exp. Sta., Route 1, Lubbock, Tex.
McCurdy, LeRoy, McCurdy & Sons, Fremont, Iowa
McKibben, G. E., Dixon Springs Experiment Station, Robbs, Ill.
McOnie, J. B., Oilseeds Development Corp., 17 Voor St., Potgietersrus, N. Transvaal South Africa
Majors, K. L., Federal Extension Service, Northern Util. Res. and Devel. Div., 1815 N. University, Peoria, Ill.
Mann, Herbert O., Southeastern Colorado Branch Station, Springfield, Colo.
Martin, J. H., Agr. Res. Service, Plant Industry Station, Beltsville, Maryland
Maunder, A. B., DeKalb Agric. Assoc., Route 2, Lubbock, Tex.
Menge, Paul, Field Corn Research Dept., Northrup, King & Co., Minneapolis 13, Minn.
Merwine, N. C., Dept. of Agronomy, Mississippi State College, State College, Miss.
Metzer, R. B., Dept. of Agronomy, Texas A & M College, College Station, Tex.
Miller, Darrell, Dept. of Agronomy, Purdue Univ., Lafayette, Ind.
Moore, R. F., Dept. of Agriculture and Stock, P. O. Box 231, Warwick, Queensland, Australia
Mudenda, E., Ministry of Agriculture, Mount Makulu Research Station, P. O. Box 7, Chilanga, Northern Rhodesia
Munoz, Juan, Rockefeller Foundation, La Paz 27, Celaya, Gto., Mexico
Newton, J. P., Dept. of Agronomy, Agr. Exp. Sta., Experiment, Ga.
Nielson, Kent, Agronomy Dept., Box 5, New Mexico State Univ., University Park, New Mexico
Noble, E. G., Southwestern Irrigation Field Station, Brawley, Calif.
Nordquist, Paul, Agr. Exp. Sta., North Platte, Nebr.
Odom, W. H., Seed Division, Missouri Farmers Assoc., Marshall, Mo.
Olson, Cliff, Cargill, Inc., Aurora, Nebr.
Osler, R. D., Rockefeller Foundation, Calle Londres, 40, Mexico 6, D.F., Mexico
Parodi, Ricardo A., Estacion Experimental Agropecuaria, Manfredi, Cordoba, Argentina
Pauli, Arland, Dept. of Agronomy, Kansas State University, Manhattan, Kans.
Pickett, R. C., Dept. of Agronomy, Purdue Univ., Lafayette, Ind.
Pinnell, E. L., Dept. of Field Crops, Univ. of Missouri, Columbia, Mo.
Poehlman, J. M., Dept. of Field Crops, Univ. of Missouri, Columbia, Mo.
Ponnaiya, B. W. X., Research Institute, Coimbatore, Madras, India
Porter, K. B., Southwestern Great Plains Field Station, Bushland, Tex.

Quinby, J. R., Agr. Exp. Sta., Chillicothe, Tex.
Rachie, K. O., Rockefeller Foundation, 20/39 Diplomatic Enclave, New Delhi, India
Raman, V. S., Agricultural Research Institute, Coimbatoire 3, India
Ramana, T. V., 25A Kirlampudi House, Andhra University, Waltair, India
Rea, H. E., Southwestern Great Plains Field Station, Bushland, Tex.
Reyes, Lucas, Agr. Exp. Sta., Beeville, Tex.
Rhykerd, C. L., Dept. of Agronomy, Penn. State Univ., University Park, Penn.
Rich, P. A., Agr. Exp. Sta., Denton, Tex.
Richardson, G. L., Division of Agriculture, Arizona State Univ., Tempe, Ariz.
Roberts, Tom Jr., DeKalb Agric. Assoc., DeKalb, Ill.
Roberts, Tom, Kansas Crop Imp. Assoc., Kansas State Univ., Manhattan, Kans.
Robinson, D. O., Division of Agriculture, Arizona State Univ., Tempe, Ariz.
Robinson, R. G., Dept. of Agronomy, Univ. of Minnesota, St. Paul, Minn.
Rogers, J. S., Asgrow Texas Co., 211 Suffolk St., College Station, Tex.
Rosenow, D. T., Dept. of Agronomy, Texas A & M College, College Station, Tex.
Ross, J. G., Dept. of Agronomy, South Dakota State College, Brookings, S. D.
Ross, W. M., Ft. Hays Exp. Sta., Hays, Kans.
Sahs, Warren W., Foundation Seed Division, Univ. of Nebraska, 3115 N. 70th St., Lincoln 7, Nebr.
Sanchez-Monge, E., Instituto Nacional de Investigacions Agronomicas, Centro de Mejora del Maiz, Avenida de Puerto de Hierro, Madrid, Spain
Schertz, K. L., Dept. of Agronomy, Texas A & M College, College Station, Tex.
Schneider, L. A., Garst & Thomas Hybrid Corn Co., Coon Rapids, Iowa
Sieglinger, J. B., Dept. of Agronomy, Okla. State Univ., Stillwater, Okla.
Sletten, W. H., Southwestern Great Plains Field Station, Bushland, Tex.
Smeltzer, Dale, Dept. of Agronomy, Univ. of Calif., Davis, Calif.
Smith, D. C., Dept. of Agronomy, Univ. of Wisconsin, Madison, Wis.
Smith, James, Dept. of Genetics, Texas A & M College, College Station, Tex.
Snowden, J. D., Mirembe, 19 Vectis Road, Barton-on-Sea, New Milton, Hants, England
Spain, G. E., Dept. of Field Crops, North Carolina State College, Raleigh, N. C.
Sprague, G. F., Cereal Crops Research Branch, Plant Industry Station, Beltsville, Maryland
Srivastava, D. P., Dept of Field Crops, University of Missouri, Columbia, Mo.
Stephens, J. C., Agricultural Experiment Station, Chillicothe, Texas
Stickler, F. C., Dept. of Agronomy, Kansas State University, Manhattan, Kans.
Stith, L. S., Dept. of Plant Breeding, University of Arizona, Tucson, Ariz.
Stokes, I. E., Tobacco and Sugar Crops Research Branch, Plant Industry Station, Beltsville, Md.
Stroube, W. H., Dept. of Agronomy, University of Kentucky, Lexington, Ky.
Sullivan, E. F., Dept of Agronomy, Pennsylvania State University, University Park, Pa.
Swanson, A. F., 417 W. 7th St., Hays, Kans.
Tahir, W. M., Tozi Research Station, Wad El Nail, Sudan
Terhune, D. D., Steckley Hybrid Corn Co., 2416 North St., Lincoln, Nebr.
Thurman, R. L., Dept. of Agronomy, University of Arkansas, Fayetteville, Ark.
Tipton, Don, Pfister Assoc. Growers, Hutchinson, Kans.
Trotter, Allen, Associated Seed Growers, Inc., P.O. Box 406, New Haven 2, Conn.
Van Niekerk, B. P., Division of Crops and Pastures, Dept. of Agriculture, Agriculture Building, Beatrix Street, Pretoria, South Africa
Vasquez, Hector, Biblioteca, Facultad de Agronomia, Casilla de Correo 125, San Miguel de Tucuman, Argentina
Ventura, Yaacov, 162 Shikoun Amami 3, Beersheba, Israel
Wainscott, D. D., Steckley Hybrid Corn Co., 2416 North St., Lincoln, Nebraska
Walter, Ted, Agricultural Experiment Station, Colby, Kans.
Washko, J. B., Department of Agronomy, Pennsylvania State University, University Park, Pa.

Watkins, P. W., Dept of Agronomy, University of Illinois, Urbana, Ill.
Watson, Clarence, Agronomy Dept., Box 5, New Mexico State University, University Park, N. Mex.
Watson, S. A., Research Dept., Corn Products Co.,P. O. Box 345, Argo, Ill.
Webster, J. E., Dept. of Agricultural Chemistry, Oklahoma State University, Stillwater, Okla.
Webster, O. J., Department of Agronomy, University of Nebraska, Lincoln 3, Nebr.
Weibel, Dale E., Dept. of Agronomy, Oklahoma State University, Stillwater, Okla.
Whitehead, Wayne, Dept. of Agronomy, Purdue University, Lafayette, Indiana
Wiese, A. F., Southwestern Great Plains Field Station, Bushland, Tex.
Wilhite, J. R., Dept. of Agronomy, Oklahoma State University, Stillwater, Okla.
Wilson, James A., Ft. Hays Experiment Station, Hays, Kans.
Wolf, I. A., Northern Utilization Res. and Devel. Div., 1815 N. University, Peoria, Ill.
Wood, E. A., Jr., Dept of Entomology, Oklahoma State University, Stillwater, Okla.
Worker, G. F., Imperial Valley Field Station, El Centro, California
Young, A. W., Dept. of Agronomy, Texas Technological College, Lubbock, Tex.
Young, Harry, Dept. of Botany and Plant Pathology, Oklahoma State University, Stillwater, Okla.
Zuber, M. S., Dept. of Field Crops, University of Missouri, Columbia, Mo.

ADDENDA:

Lyons, E. S., U.S. Sugar Crop Field Station, Cairo, Ga.
Swallers, Clarence, Dept. of Agronomy, N. Dak. Agr. Exp. Sta., Fargo, N. Dak.